Wolverton.Bailey Innovations

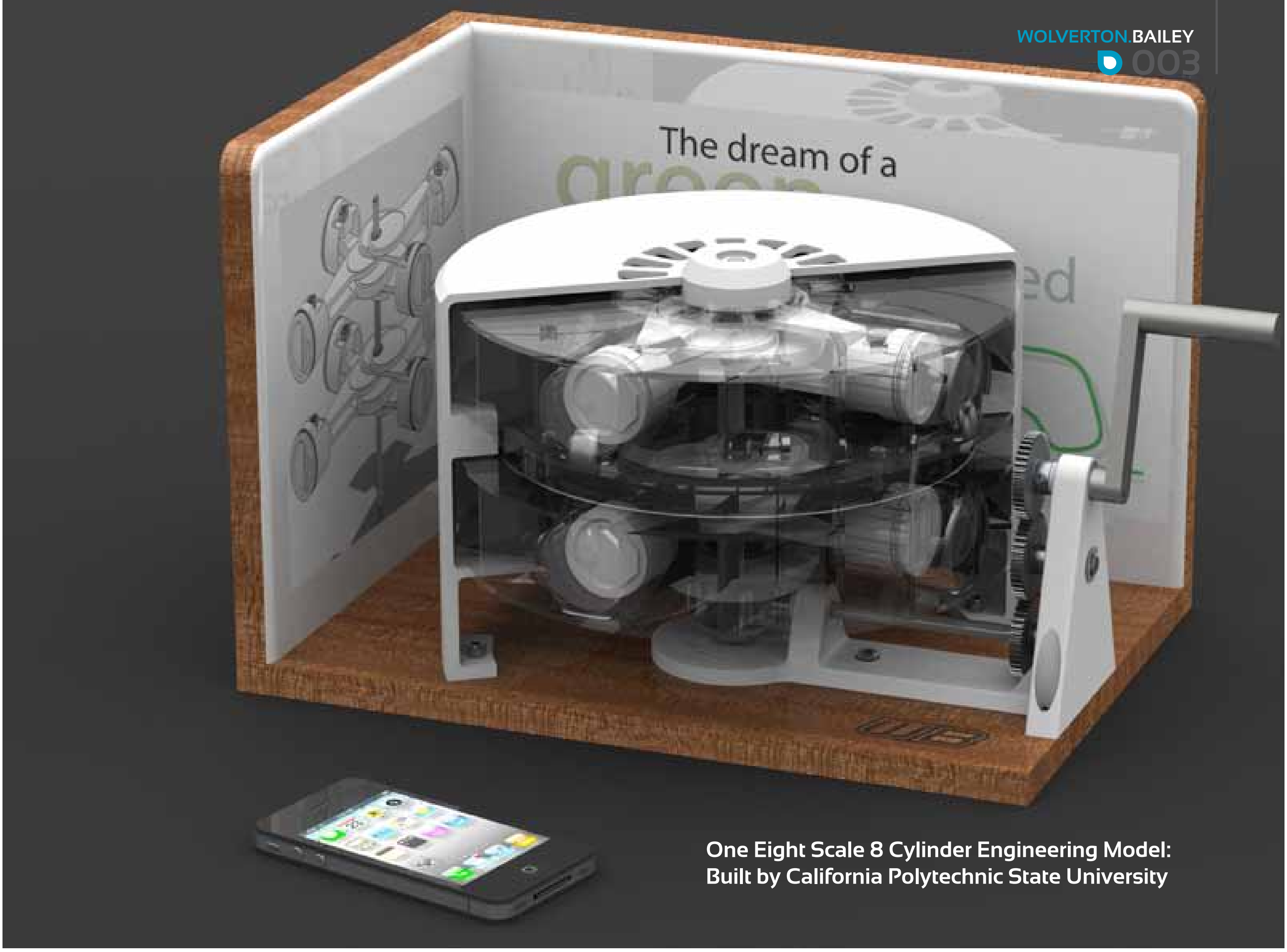
Counterpoise^{tm} Engine Technology

Better **Geometry**. Better **Physics.**
A Better Internal Combustion Design.

MOTORS TO POWER OUR FUTURE

EIGHT CYLINDER COUNTERPOISE MODEL

Shown is a Desk Top 8 Cylinder Counterpoise Engine Engineering Model:
Built by California Polytechnic State University.



One Eight Scale 8 Cylinder Engineering Model:
Built by California Polytechnic State University

COUNTERPOISE TECHNOLOGY. THE FUTURE OF ENGINES & MOTORS

Wolverton.Bailey Innovation's Counterpoise technology combines the features of both static and rotary engines. Similar to the Siemens-Halske Sh. III [1] the crankshaft and the engine case rotate in opposite directions. Counter-rotation is where the similarities in engines stop. Nahum [3] explains the problems with traditional rotaries, none of which are shared by the Counterpoise engine. Counterpoise design additionally employs an offset bore to develop higher torque than in the cylinder assembly. The geometry of the Counterpoise™ engine offers a huge improvement in efficiency over that of a conventional Otto engine. The torque of the engine is immediate and increased in each cycle.

In addition, the engine cycle is completed in a single counter-rotation, reducing friction and heat lost. The cost of rotating the bore is offset with the complete elimination of the valve train providing a huge net gain in overall efficiency.

A Counterpoise™ engine is smaller, yet provides more power output – Trials estimate 2.37 horsepower per pound of engine weight. Key attributes include:

> 165% More Power To The Wheels
> Revolutionary Rotating Bore
> Incorporates Best Effects of Atkinson, Miller, and Otto Engines.
> Unprecedented Power Density – 2.37 HP Per Pound of Engine Weight
> Superior Low RPM Torque
> Reduced Cooling Requirement
> Uses Standard Round Pistons & Rings, etc.

> Engine Sizes - 15hp to Any Scale - [no upper limits]
> Fuel Choice Flexibility
> Double the Power Strokes Per Engine Cycle
> Double the power stokes per 720 degrees

Why is the...

COUNTERPOISE SUPERIOR?

AMONG IT'S MANY IMPROVEMENTS, COUNTERPOISE DESIGN ELIMINATES KEY EFFICIENCY REDUCING FLAWS IN THE OTTO ENGINE DESIGN WHICH CAUSE AN IMMEDIATE 60+ % DROP IN THE EFFICIENCY OF EACH ENGINE CYCLE .

Overview of Basic Engine Efficiency

The thermodynamic efficiency of an actual engine is roughly 0.8 times that of the fuel-air cycle.

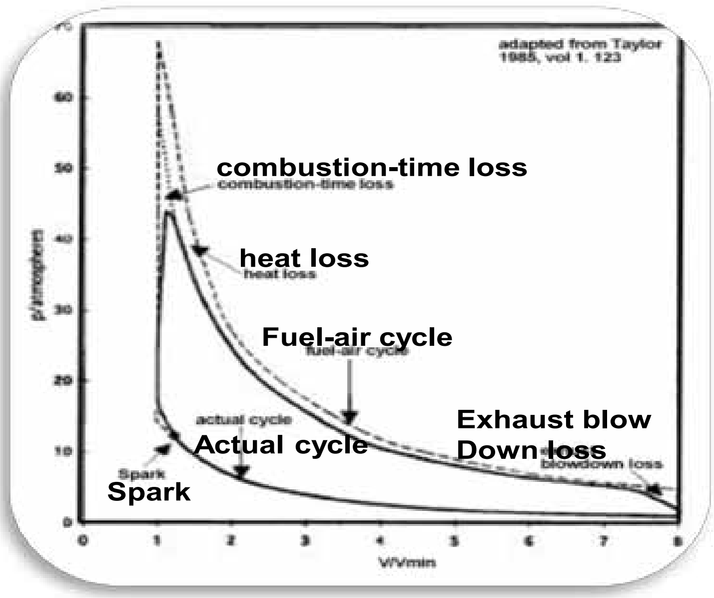
The ways in which capacity to do work is LOST relative to the fuel-air cycle are:

1. Heat loss: heat escaping through the cylinder walls, (cooling system)

2. Combustion-time loss: delay of some combustion until well into the expansion stroke. Current engines must fire before top dead center which makes the engine essentially work against itself for a short duration and increases combustion temperatures dramatically. All this unused heat is mostly carried away by the cooling system.

3. Exhaust blow down: pressure release when the exhaust valve is opened.

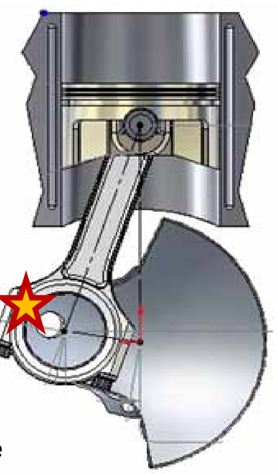
4. Fuel that is not burned within the cylinder. Typically about 2% of fuel input.



A REVIEW OF THE LESS THAN OPTIMAL PHYSICS OF OTTO ENGINE DESIGN:

To be able to put numbers to this illustration, we'll model a Small-block V-8 engine. The bore (diameter of the cylinder) is 4", and the stroke (twice the crankshaft throw radius) is 3.5". The volume of that cylindrical volume is then (PI) * R2 * H or 3.1416 * 2 * 2 * 3.5 or around 44 cubic inches. Since that engine has eight cylinders that are each that same volume, its total 'displacement' is 44 * 8 or around 350 cubic inches. Hence we have a 350 V-8

Since our example engine has a compression pressure of 120 PSIA, this results in a momentary explosion pressure that peaks at around 500 PSIA. Since the piston is 4" in diameter, the top surface of it is just PI * (4/2)2 or around 12.6 square inches. Each of those square inches experiences the 500 PSI(G) pressure, so the total force then instantaneously applied to the top of the piston is 12.6 * 500 or around 6300 pounds.



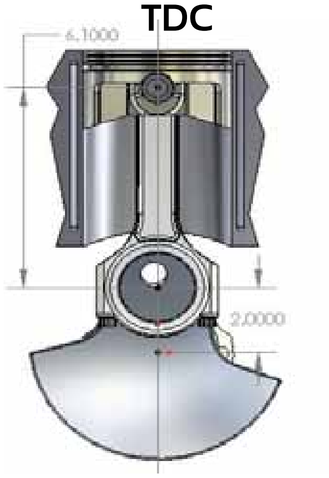
Engines actually need to fire Before **TDC. It's called Spark Advance**

Mark's Standard Handbook for Mechanical Engineers, Section 9 states that the optimum spark advance is approximately 5/9 of the combustion time. This means that more time of combustion happens BEFORE TDC than after!

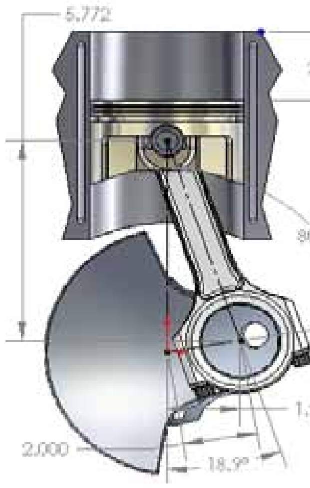
This makes the point that the more powerful portion of the combustion comes late in the combustion process, and helps overcome that 5/9 of combustion that acted to try to make the engine spin backwards.

The early part of the combustion process is burning fuel and building up pressure, but the TOTAL pressure is somewhat cumulative. Think of this as the Calculus Integral of the pressure over time. So even though 5/9 of the TIME of burning may occur before TDC, the PRESSURE is still not fully developed, and the cumulative pressure AFTER TDC is much higher which is why the maximum torque is developed when the spark is advanced around 5/9 of the total combustion time. But note that ALL of the combustion needs to be done before the piston is able to move very far down the cylinder, meaning that the maximum force (pressure) is developed fairly close to when the crankshaft throw is nearly straight up, **the worst possible mechanical (dis)advantage.**

TDC



At the point the crank approaches 45 degrees the effective compression pressure is down to a 2:1 compression ratio. Combustion pressure is now around 125 PSIG and the total force on the piston is around 1600 pounds. Even though the geometry is NOW the best possible, the total torque transferred to the crankshaft has DROPPED. It's now 1600 * 1.0 * 0.146 or around 230 foot-pounds of torque This calculation is in "ballpark" agreement with the published maximum torque curves for a 350 V8 engine at 1500 rpm.



More optimal angles after TDC

ENERGY LOSSES

Poor Physics of Otto Design

STAGE 1.

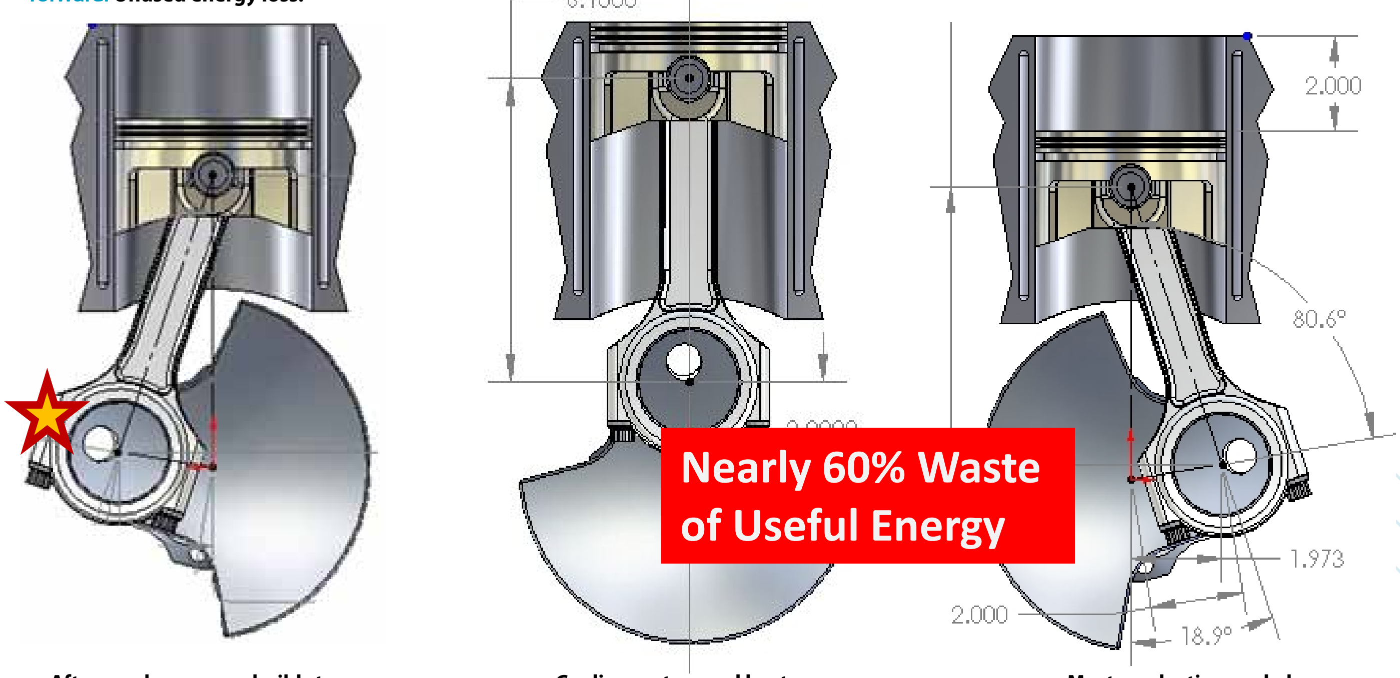
Engine Must Fire Before TDC and wants to spin backward. The flame forward, flywheel, etc. acts to pull the piston forward. **Unused energy loss.**

STAGE 2.

Zero work contribution at TDC as pressure here would act to push engine out of its frame. **Energy is Lost.**

STAGE 3.

Combustion Time Delay Loss
Our **6300 pounds** of pressure has dropped off to **1600 pounds** for productive work.



After spark, pressure builds to around 6300 pounds

Cooling system and heat rejection cause huge losses.

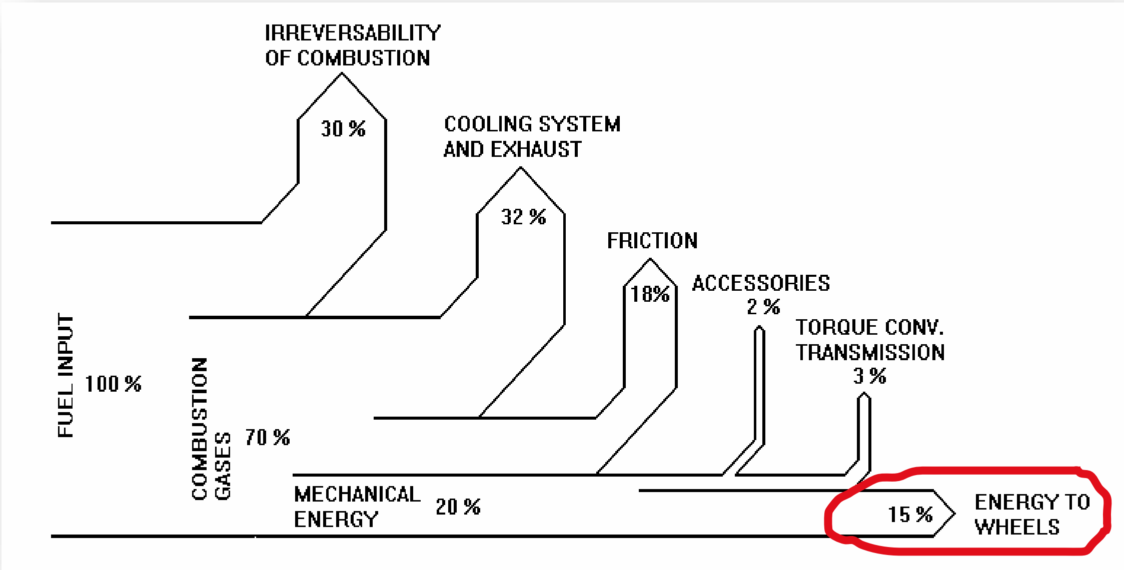
Most productive work done here, but pressure has dropped to around 1600 pounds.

Depending on exactly where the spark plug is located, that flame front must travel two to four inches in order to ignite all the gases in the cylinder. At 90 ft/sec, this then requires around 0.002 to 0.004 second for the combustion to complete. This might not sound like much, but engines spin amazingly fast, and these brief time durations of combustion always take many degrees of crankshaft rotation. So even though the ignition occurred BEFORE TDC, and the very start of the combustion actually acts to try to make the engine run backwards, the ignition timing is carefully scheduled so that MOST of the combustion (and therefore combustion pressure on the piston head) occurs AFTER TDC. In this diagram (Figure 3), bBy the time that a maximum amount of the gas-air mixture is burning, the crankshaft has rotated a slight distance past TDC. This situation, and its consistency (due to consistency of the quality and burning characteristics of the gasoline), enables a modern engine to avoid seriously trying to spin backward. s! The mathematics below shows that, for an engine speed in a normal driving situation of around 1500 rpm, (a normal driving situation) this is commonly around 10° AFTER TDC, when the greatest explosion pressure is present in the combustion chamber.

Let's look at some preliminary calculations. It is very well established that the explosion, and therefore the heat created, causes the gases in the combustion chamber to obey standard rules of cChemistry, such as the Ideal Gas Law. Because of the sudden heat, the gases try to expand immediately, but they cannot, so the pressure in those hot gases greatly and rapidly increases. Very consistently, the explosion pressure in an internal combustion engine rises to between 3.5 and 5 times the compression pressure. Since our example engine had a compression pressure of 120 PSIA, this results in a momentary explosion pressure that peaks at around 500 PSIA. Since the piston is 4" in diameter, the top surface of it is just PI * (4/2)2 or around 12.6 square inches. Each of those square inches experiences the 500 PSI(G) pressure, so the total force then instantaneously applied to the top of the piston is 12.6 * 500 or around 6300 pounds. It is ACTUALLY the 500 PSIA, but there is natural air pressure pressing against the underside

THIS CHART FROM THE

Physics Department of the University of Michigan Illustrates the **Fuel In-efficiency** and Physics of Current Engines



Source: FUEL EFFICIENCY AND THE PHYSICS OF AUTOMOBILES 1
Marc Ross, Physics Department, University of Michigan, Ann Arbor MI 48109-1120

of the piston as well, so the net effect we are interested in is due to the gauge pressure—. (nNot too different, but slightly.!)

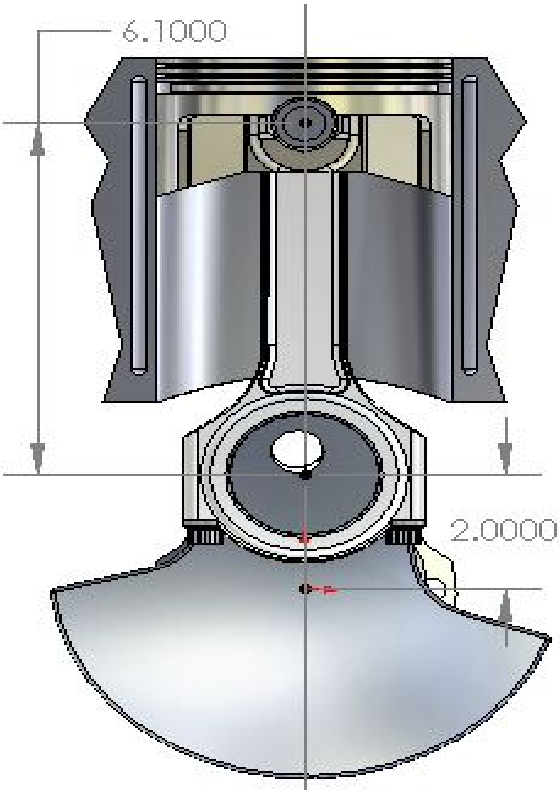
Because of the geometry of the situation when the crankshaft has progressed 10° after TDC, the force diagram indicates that this downward force must be multiplied by, (approximately,) the sine of 10°, in order to determine the tangential force applied to the crankshaft. Approximately, because the connecting rod is no longer parallel with the axis of the cylinder bore, the actual angle being slightly higher, and an exact angle is easy to calculate with a thorough analysis. For now, 10° will give an approximate result for our purposes. Therefore, the tangential (rotative) force actually transferred to the crankshaft is around 6300 * sin(10) or 6300 * 0.174 or around 1100 pounds. Since this force is applied to the throw of the crankshaft, at 1.75" radius from the centerline of the crankshaft, the torque transferred to the crank-shaft is therefore 1100 * 1.75" or 1100 * 0.146 foot or 160 foot-pounds of torque. This calculation is in "ball-park" agreement with the published maximum torque curves for such engines, at 1500 rpm. Notice that the radial force applied to the crankshaft (bearings) is around 6300 * cos(10) or around 6200 pounds! At that moment, the vast majority of the power of the explosion is trying to drive the crankshaft down out of the engine, without rotating it!

In traditional automotive thinking, as long as the piston rings do not leak too much and the valves do not leak too much, then those expanded gases inside the combustion chamber cannot escape until the exhaust valve starts to open, and all the pressure will act to push the piston downward. This means that having the maximum pressure developed as soon as possible after TDC gives the most possible available degrees of productive crankshaft rotation. The benefit of this is seriously affected by the fact that, as the piston moves downward, the volume inside the combustion chamber increases, so the pressure drops (Ideal Gas Law).

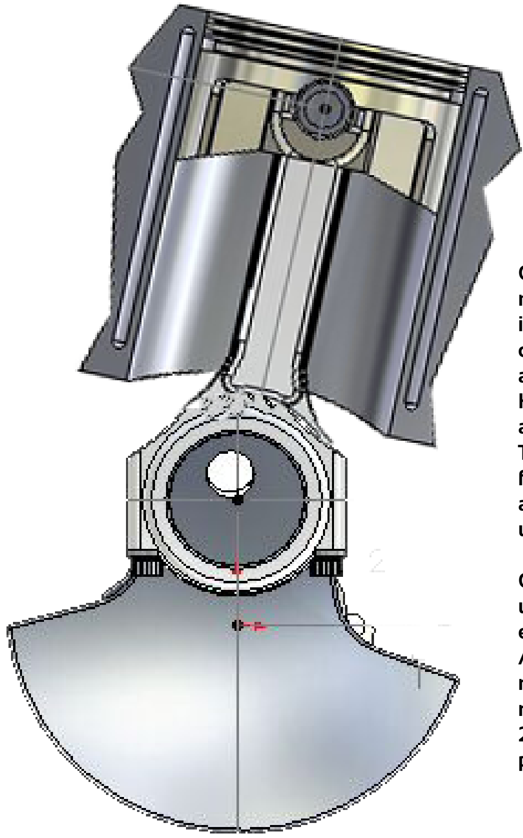
From a beginning combustion pressure of 500 PSIG in our example, at the later instant when the crankshaft had rotated 45°, the volume has increased such that the pressure drops to around 200 PSIG (without any leakage;) and by the time the crankshaft has advanced 90°, the pressure is down to around 125 PSIG. The AVERAGE pressure during this 90° of rotation is referred to as Mean Effective Pressure (mep) and is commonly around 200 for common engines under power.

This is part of the reason why Otto cycle engines have such terrible overall efficiency, rarely higher than the low 20% range.

Otto TDC



Counterpoise TDC



Optimal geometrical mechanical position is designed Into counterpoise piston and bore angles. Here shown at about 11 degrees. This off-set allows for immediate and additional capture usable energy.

Our design also utilizes action like every engine, but ALSO uses the heat rejection to counter-rotate the bore for 20% additional power.

COUNTERPOISE IMPROVEMENTS

COUNTERPOISE VERSION OF THE SMALL-BLOCK 350 V-8 ENGINE.

Notice the Counterpoise Equivalent of TDC: The piston and bore are slanted to an optimal mechanical angle. Counterpoise pistons are not set perpendicular to the crankshaft and the pistons do not reciprocate, but travel in an oval path.

In a Counterpoise™ version of the Chevy 350 engine, our crankshaft throw sits at an **optimal angle** for the **greatest possible geometrical mechanical transfer of torque** to the crankshaft.

At the same time the resultant cylinder wall pressure acts to counter-rotate the bore. Creating a situation where more of the 6300 pounds force on the piston is applied to WORK — optimal angles reduce combustion delay— so the torque transferred to the crankshaft remains near 4400 pounds of force or 4400 * 1.0 * 0.146 or about 642 foot-pounds of torque instead of the 230 foot pounds provided in the Otto configuration.

Even considering yet unknown losses, Counterpoise™ technology offers more output power, relative to energy input and engine size, of any automotive engine, ever.

Key Point to Note: Counterpoise engines deliver 2 power strokes per 720 degrees of cycle. Meaning a 4-Cylinder Counterpoise engine would provide the same number of power strokes as an Otto 8 cylinder, and more power.

There are obvious efficiency increases from extracting more work from half the cylinders. Then there is the savings of fuel input and emissions from each cylinder.

Action & Reaction is utilized in Counterpoise design.

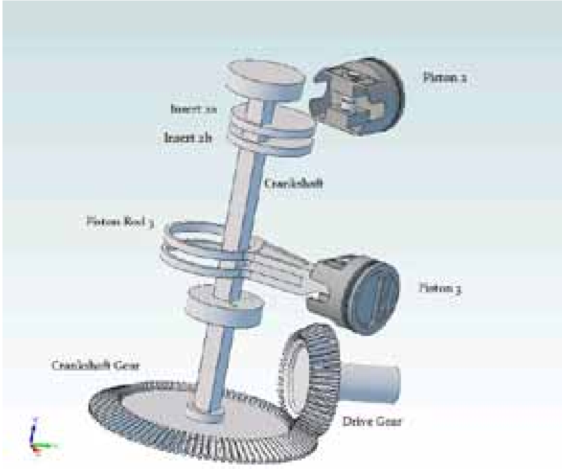
Instead of wasting the nearly 60% of energy created by the fuel input, Counterpoise engines use the Reaction to "Propel" the Bore Assembly away from the Crankshaft with greater force than the Piston Rod exerts on the Crankshaft.

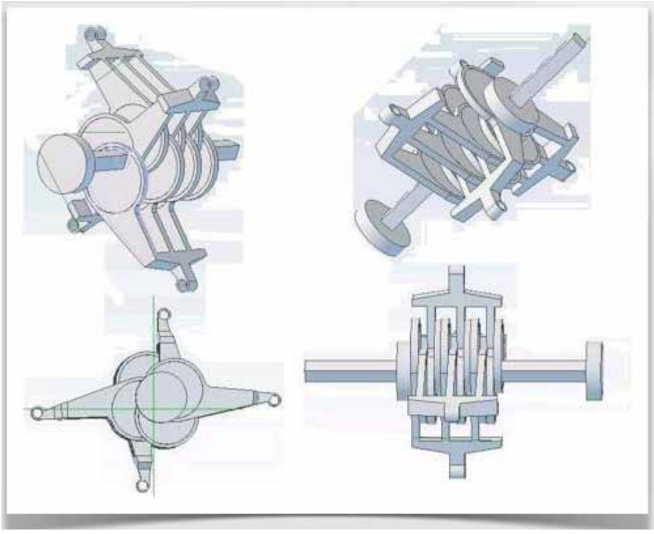
"How is this possible?" is the first question we are always asked. In the engineering model we use a 4 inch bore and a 3 inch stroke. This means that the Crank Offset for the Piston Rods is 1.5 inches, from the center of the Crankshaft and the Crankshaft Gear. A simple division will show that 1 foot divided by 1.5 inches gives us a conversion factor of 8. This conversion factor is the number you divide into the pounds of pressure on the crankshaft to find output Foot Pounds. At the other end of the Action Reaction pair, the ceiling of the bore is 12 inches from the center of the Crankshaft, and the pressure applied can be measured in Foot Pounds.

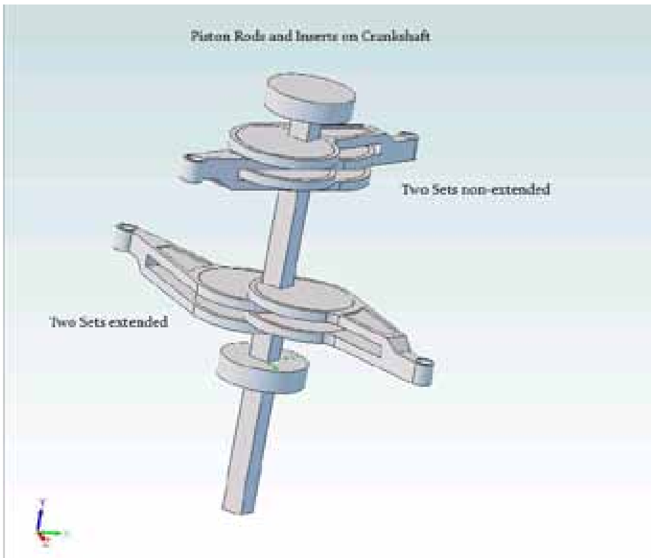
The conversion factor on the ceiling has to do with the ANGLE of the pressure, not the distance. With the proper slant ANGLE for the bore, we demonstrate the Bore Assembly torque is much greater than torque from the Crankshaft.[*Our patent application claims all useful angles*]

Counterpoise Technology Combines The Energy. The torque from the Crankshaft and Bore Assembly are combined at the Drive Gear, which by the way also keeps the Crankshaft and the bore Assembly in angular sync.
The Bore Assembly is connected through the Body, (through a bearing) to the Bore.

Gear. The Crankshaft is coaxial with the Bore Assembly and outputs through the bearings to the Crankshaft Gear, because the crankshaft rotates counter to the Bore Assembly, it will mesh with the Drive Gear on the opposite side from the Bore Gear. The power applied to both sides of the Drive Gear is then at an RPM that is determined by the ratios of these gears. [There is of course an idler gear.]

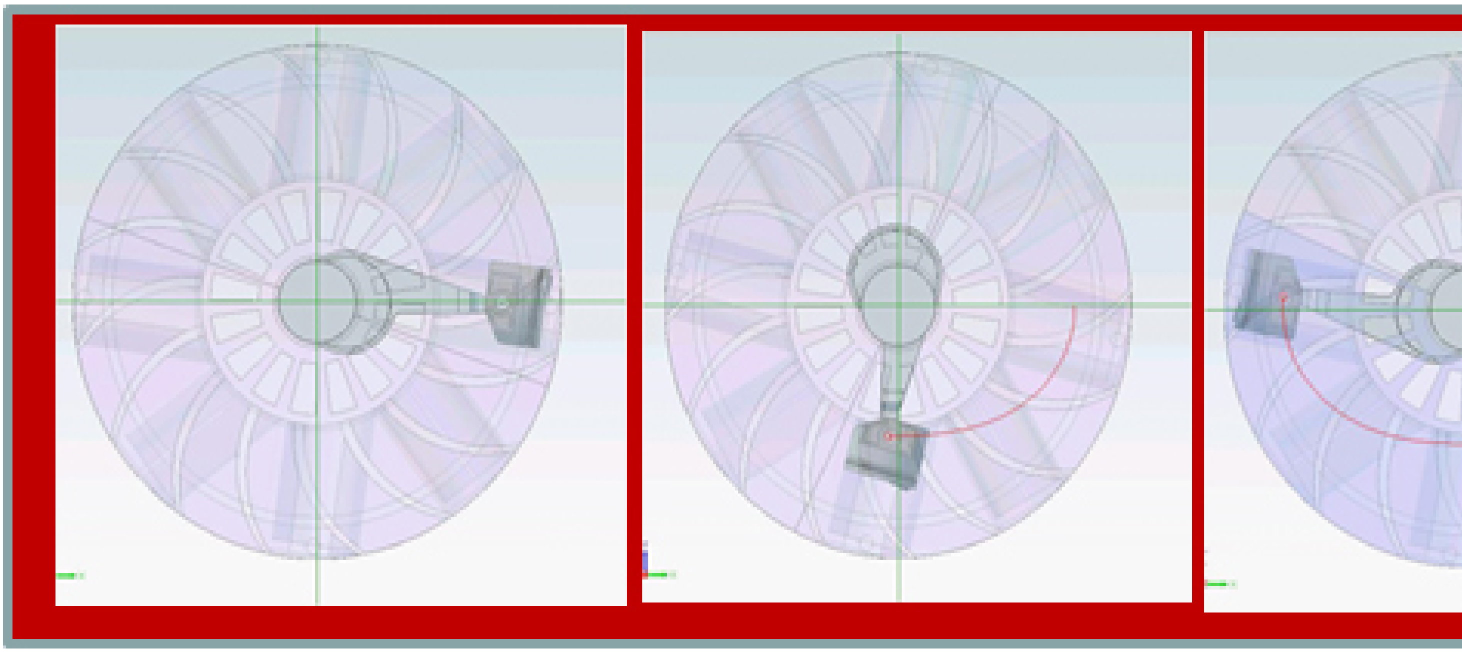






"OUR SIMPLE, CHEAP TO MANUFACTURE CRANK AND ROD CONFIGURATIONS"

PISTON PATH IS AN OVAL



Power Stroke

Finish Power Stroke

Begins EXHAUST

**Completes 8
The bore ass
Clockwise 18
crankshaft h
clockwise ar
This is the sa
revolution o
in a regular C
Begins EXHA**

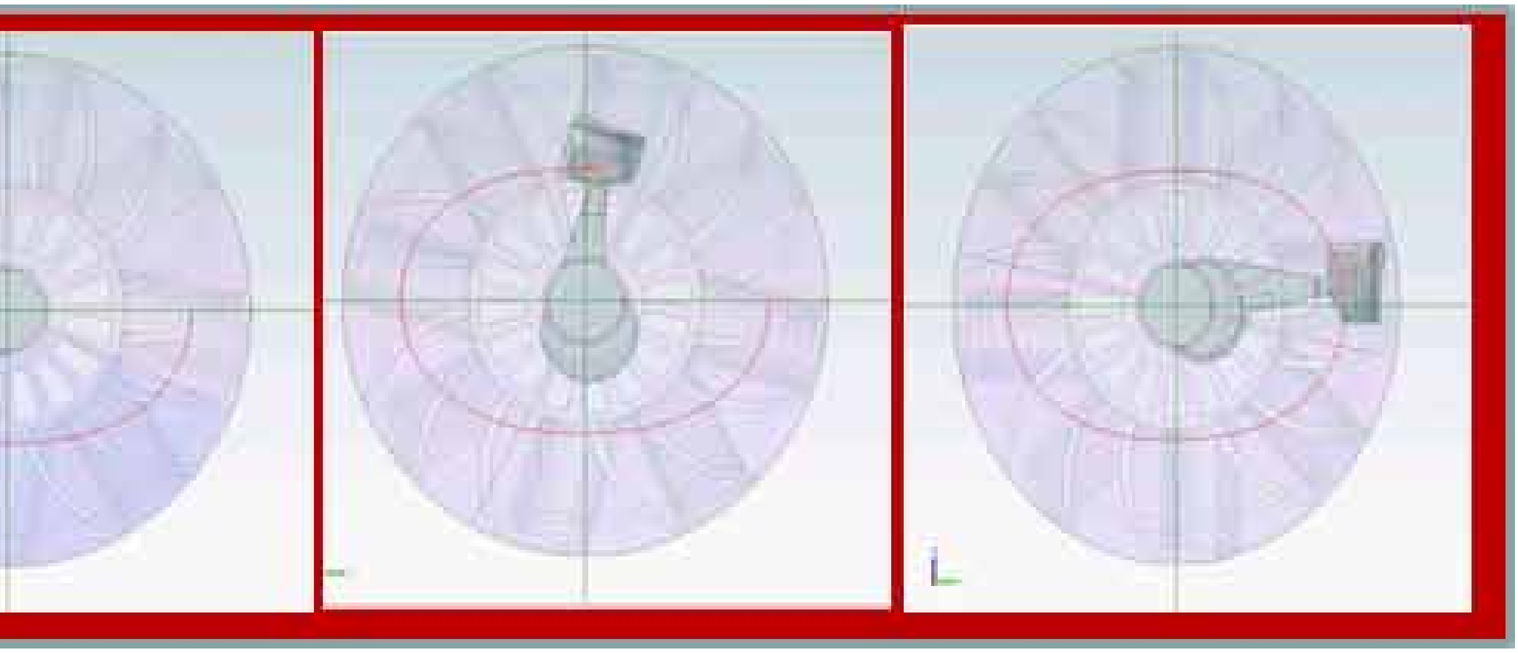
The Piston, Wrist Pin, Rod, Insert and End Bearing are shown while the Bore assembly is shown transparent to allow you to see the path of the piston.

We are using the trace property of the CAD program. The exact location of the Wrist Pin will be drawn in RED. The first block shows the location of the piston just before the spark ignites the fuel mixture at the start of the "Power Stroke" in the sequence known as:

Intake; compression; Power and Exhaust.

Counterpoise engine sends energy in opposite directions, finishing the engine cycle in 360 degrees instead of 720 degrees, and delivers two power strokes per 720 degrees.

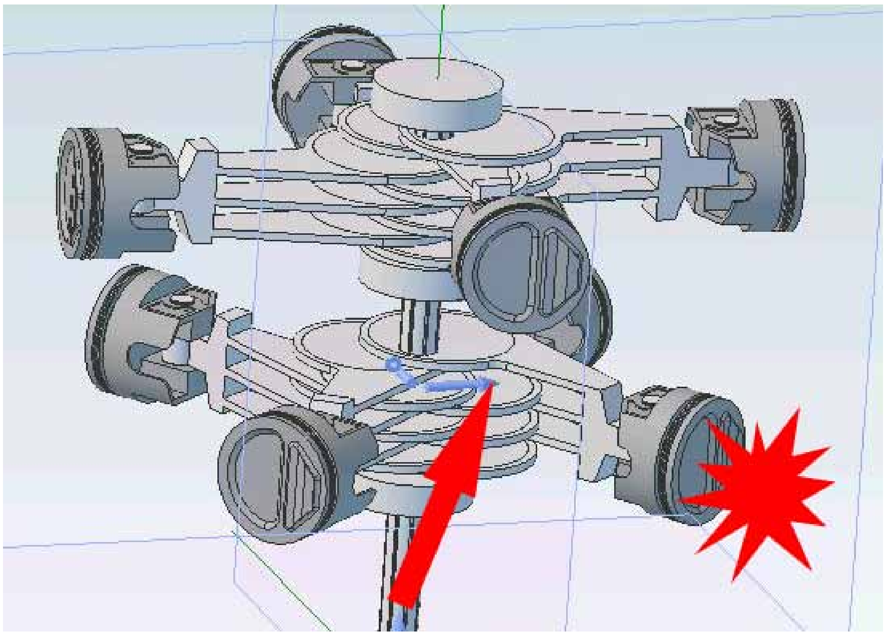
The Bore and the Crank is Rotating – Therefore the counterpoise engine completes The 4-cycles in a single rotation, instead of the two rotations required in Otto engines.
The Valve-train is eliminated.



& Begins INTAKE.
sembly has rotated
30 degrees while the
as rotated Counter-
n equal amount.
ame as a complete
f the Crankshaft
Otto-cycle engine.
AUST

Compression

Cycle begins again.

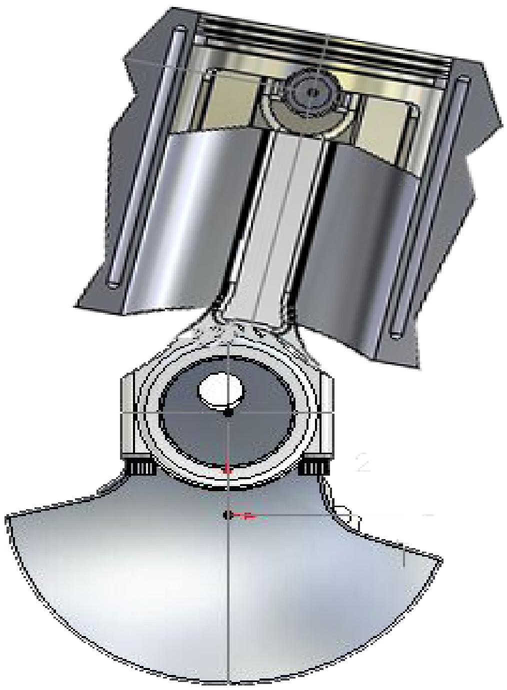


PATENT PENDING BORE ANGLES

Determine Engine Characteristics

Table 1.

Offset Angle (absolute)	Application
0-3 degrees	Small, highly responsive engines (e.g., sport vehicles)
3-7 degrees	Larger, high torque engines (e.g., small trucks, luxury vehicles)
7-12 degrees	Premium, special purpose engines (e.g., generators, trains, ships, power plants)
12-45 degrees	High wear, highly maintained engines (e.g., tanks, militarized machinery, research engines)
45-90 degrees	Future platforms



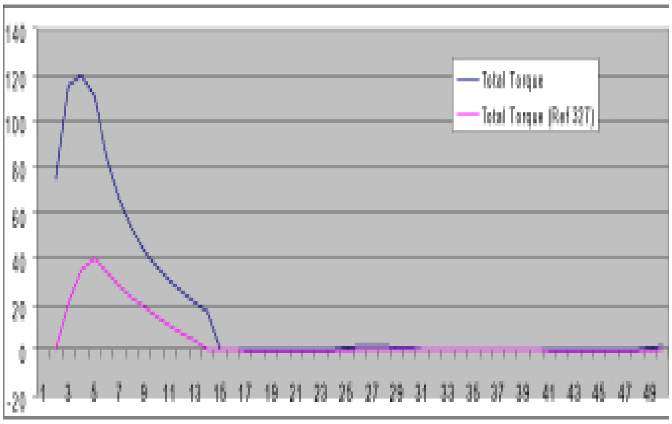
Extracted from Patent Application:

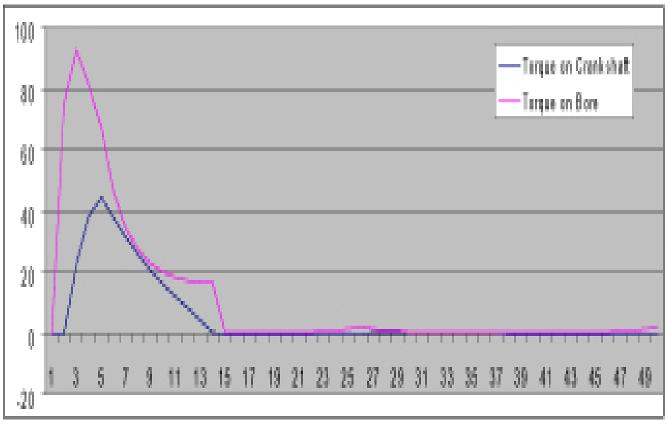
[0051] With further regard to the offset angle, it has been determined that an offset angle of -2 degrees from TDC can provide an engine with equivalent torque as a conventional engine using half as many cylinders. Moreover, depending on the application, the offset angle might be established (on a fixed or variable basis) as shown below in Table I.

The Counterpoise technology includes a variable bore design.

THE BENEFITS OF ROTATING THE BORE

The chart below illustrates a comparison of the power output of our Counterpoise design to a sample engine. The chart illustrates that the "per cylinder" power of the Counterpoise engine is nearly three times greater.





Twenty percent of the counter pressure is rotational and usable, but it is applied at 10 inches from the center of the crankshaft during the full power stroke. No SIN offset.

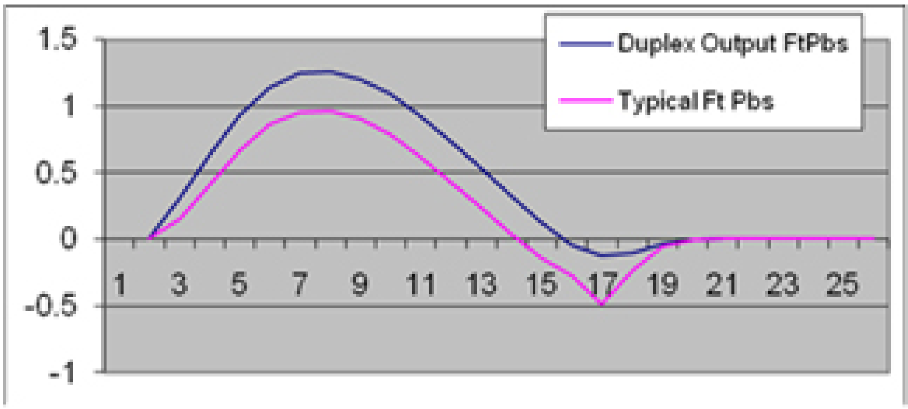
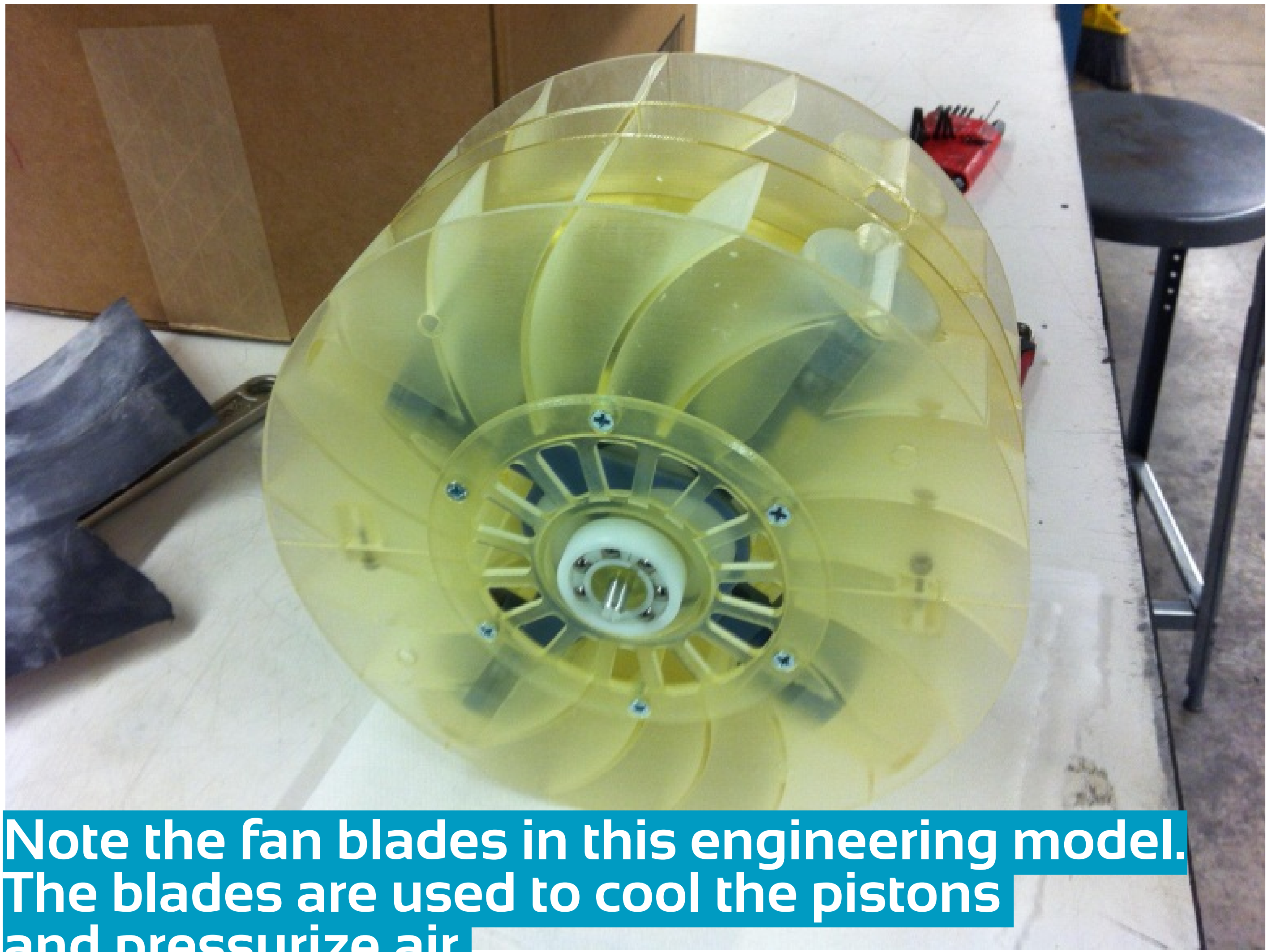


Chart C. Work output Advantage of counter-rotation over a fixed bore.

A simulation output is shown in Chart C to examine the difference between allowing counter-rotation and holding the bore fixed. The scale of the graph is 0-720 degrees for both cycles due to the method of calculation used. The notable change is that the instantaneous torque has increased. It is important to remember that the Counterpoise engine is designed to achieve the four cycles of the "Otto" engine in 360 degrees rotation of the Crankshaft. This is done by rotating the Bore Assembly Counterpoise to the Crankshaft, a matching 360 degrees. The sum of these two rotations give the 720 degrees required by the "Otto Cycle". There is significant gain to be seen by this single rotation of the crankshaft. Beside the reduced friction and improved flywheel effect, we can demonstrated that there is an advantage when introducing valves to the engine for higher compression ratios.



Note the fan blades in this engineering model. The blades are used to cool the pistons and pressurize air.

MECHANICAL LOSS COMPARISON

Rotational Losses

The most obvious difference of the WBI engine from a traditional Otto cycle engine is the counter-rotation of the cylinders. This large rotating mass has a number of effects on the dynamics of the engine. It will act as a large flywheel, eliminating the need to add this inertia elsewhere in the system. WBI addresses the potentially limiting windage concerns of a large rotating shape by encasing the engine in a fixed case and using the rotation for cooling and for compression options, such as creating a Miller engine effect on air-intake without adding additional components

Transmission Losses

An additional source of minor losses is in the addition of two extra bearings and an extra gear mesh to accomplish the counter-rotation. This added friction is not a significant portion of wasted energy at rotation in this engine, and the Counterpoise™ engine is carefully balanced with an extended connection rod to reduce friction on the sidewall from offsetting the engine.

Valve-train Losses (Cams, flywheel, etc.)

The typical valving system involves at least a belt for power transmission, bearings for a camshaft, and the repeated compression of springs to open and close valves for every cycle. Counterpoise™ technology eliminates the valve-train completely, and instead uses a slip-valve design with the effect of opening and closing ports virtually instantly. Rather than the existing situation in current Otto engines where each valve gradually opens due to the leverage of the camshaft lobe, Counterpoise™ engines allow immediate and full flow. A standard camshaft lobe causes each valve to follow a (roughly) sinusoidal path regarding being opened. The exhaust valve must open before the power stroke has completed in order to get proper valve timing (which allows valuable energy to be lost out of the exhaust.) A mathematical integration of that motion shows that the actual total airflow in the Otto design is only approximately half of what is theoretically possible.

Our slip port design means that valves SNAP open and closed, which improves every aspect of engine performance enormously:

> There is NO wasted gas-air mixture passing through the cylinders, because those two valves are NEVER both open at the same time! **Better fuel mileage!**

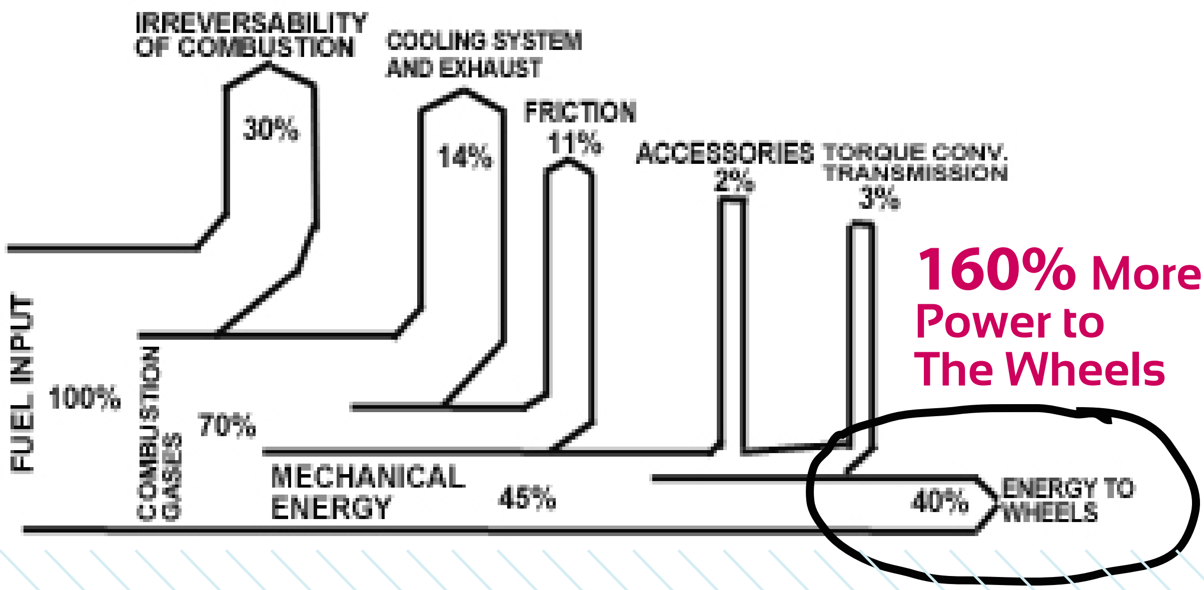
> The exhaust valve is NEVER open until AFTER the power stroke is totally completed, so an increase results in the net power output from the engine.

> With the intake and exhaust valves being fully opened instantly, far easier and better flow of fuel into the cylinder occurs, meaning greater engine power output, and far better purging of exhaust gases, allowing more available volume in the cylinder for the next incoming intake stroke.

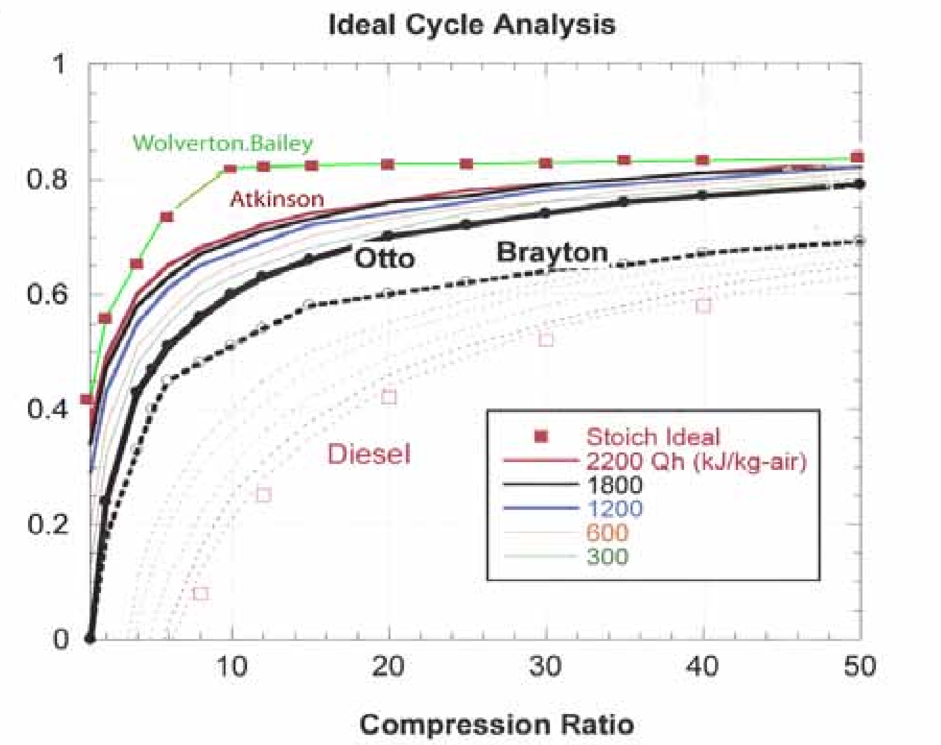
Counterpoise™ technology means BETTER fuel mileage AND much greater power production!

WBI SIMULATION
FUEL EFFICIENCY

This Chart From WBI Simulations Using Air-pressure Instead of fuel Illustrates the future fuel efficiency and the physics of Counterpoise engine:



Our Vision of Future Ideal Cycle Analysis:



FINAL **WORD.**

Imagine that in the year 1880 **(prior to the Atkinson cycle**) one was looking at the Ideal Cycle Analysis Chart. We would see that the Stoich Ideal would be coincident with the Otto cycle as that was the most efficient engine, and it described the ideal cycle.

We can assume that in 1882 with the new fruit of the Atkinson cycle added to the knowledge base, the Ideal Cycle Analysis Chart had to be modified, moving the Stoich Ideal to be coincident with the more efficient Atkinson cycle.

One would also expect the same change in the Stoich Ideal to have taken place in the 1940s with the introduction of the Miller cycle (not shown on the provided chart), which added a blower to the engine to improve power. However, the energy required by the blower also lowered the efficiency of the engine and as such, the Stoich Ideal remained coincident with the Atkinson.

Therefore, when new fruit (WolvertonBailey) is indicated, there is a reason to revisit the data and do the complete research. Should the new fruit indicate efficiency higher than the Atkinson, then the Stoich Ideal has been redefined. It would be drawn coincident with the new fruit!

As we see it the Otto cycle was able to deliver sufficient torque to become the de facto standard for 130 years. With the Atkinson cycle and Miller cycle only now achieving recognition in an industry ready to demonstrate more efficient engines, while trying to satisfy a consumer base trained on power and luxury. They do have acceptable power to accomplish minimal improvement.

The Atkinson cycle is able to provide a shorter compression cycle while delivering power on every rotation of the crankshaft, **So does the WolvertonBailey cycle!**

The Miller cycle is able to provide extra power by pressurizing the input mixture to the input cycle, **So does the WolvertonBailey cycle!**
Engines built for the Otto cycle are most reliable because it uses the round piston ring and seal configuration, **So does the WolvertonBailey cycle!**

The WolvertonBailey engine, using the patent pending counterpoise bore assembly captures action and reaction from the expanding mixture, ***no other engine does!***
The WolvertonBailey engine uses mechanical advantage for output torque from the bore assembly to add to the torque from the crank, ***no other engine does!***

The WolvertonBailey Counterpoise engine is the "new fruit" of the twenty second century, and will revitalize the American manufacturing industry.

We offer a revolutionary design!

WE'RE READY TO BUILD GAS ENGINES

And we're seeking development / licensing partnerships to build gas burning prototypes. For an advance development fee of $350,000 WBI will build a prototype of an engine with the characteristics our partner requires. Development fees will be applied to future licensing agreements at an agreed multiple of the amount.

We are open to projects for:

Marine engines
Car & Light Truck Engines
Heavy Truck /Bus Engines
Industrial motors
Generator Motors
Ship Engines
Tank / Military Engines
Sports /Race Car Engines
Concept Cars *[.i.e. Let's make a Hummer or Pickup Truck do 60 Mpg before we hybrid the engine.]* **Note:** ***Counterpoise technology includes a hybrid-engine using our rotating bore as the prime mover.***

California Polytechnic State University has agreed to work with Wolverton.Bailey on all engine development projects, and to use their casting and machine shop, computer labs, and engine starter equipment to aid our development efforts and those of our development partners.

There is also the option to build prototypes at the partner's or a third party R&D Facilities.

Interested parties, please contact:

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