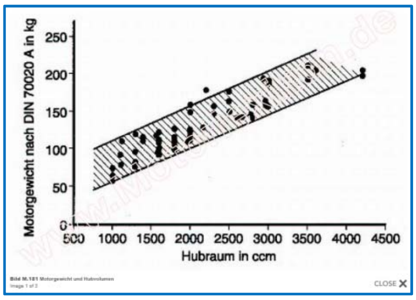
Advantages of the Hüttlin-Kugelmotor®
over the reciprocating piston engine

The Hüttlin-Kugelmotor® corresponds with a four cylinder reciprocating piston engine because each full work stroke, consisting of intake, compression, ignition and exhaust, occurs every 180°. In order to take this into account all comparisons below are made between the prototype Hüttlin-Kugelmotor® 1,180 cm^3 and a similar reciprocating piston engine.

1. Smaller and lighter

A lower engine weight and the reduced space requirements are of increasing importance, not only because of the fuel consumption, but also because of spatial considerations and an unfavourable weight distribution in light weight vehicle construction. The Hüttlin-Kugelmotor®, referred to by the abbreviation HKM, so a pure internal combustion engine with the electrical components weighs approx. 60 kg, a very light-weight reciprocal piston engine weighs at least 80 kg (see chart from www.motorlexikon.de). An engine weighting 20 kg less means, just for Switzerland alone, an annual reduction in fuel consumption of 79,375,800 litres of fuel, as calculation in the graduation paper by Lukas Keller and Jürg Studer (see Appendix 1).

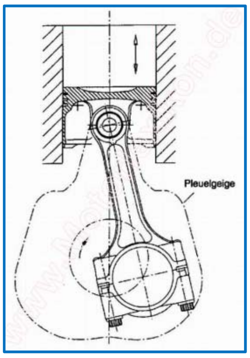


The Hüttlin-Kugelmotor® as a hybrid has a diameter of 405 mm. Because of the spherical shape an engine with a larger cylinder capacity is not much larger. A reciprocating piston engine on the whole is larger in any case, also because it contains many more components – ration 63:240 (see Appendix 2).

2. More economical in consumption

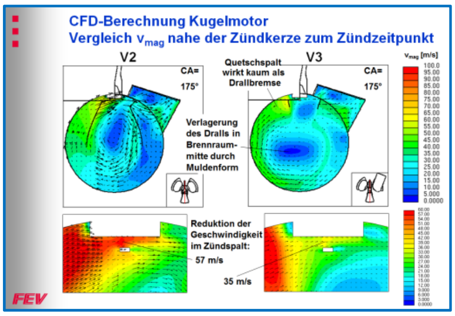
The reduced weight and the fewer moving components are the first, more obvious contribution to the fuel consumption reduction. But primarily the low intrinsic resistance and the ignition in a combustion chamber with a counter-piston reduce the fuel consumption substantially.

Because both piston pairs are guided on a central axis it is ensured that the piston never actually come into contact with the cylinder walls, so that there is no resistance or friction except that on the sealing rings, as in the reciprocating piston engine, but there this cannot be ensured due to the constant changing of the connecting rod angle (see diagram); the pistons come into contact with the inside of the cylinders on all sides.



When looking at the combustion chamber an essential difference is striking: in the reciprocating piston engine the ignition explosion can only expand in one direction, above it there is the cylinder head, and only the piston can be pushed down. But the explosion has the tendency to expand spherically, so it is blocked from above and must be redirected downwards. The further the piston moves away the larger the combustion chamber becomes and with it the distance to the initial ignition, so the mixture combustion is less efficient.

In the Hüttlin-Kugelmotor® both pistons are pushed away from the ignition. This way the flame can expand much more spherically, reflecting the nature of an explosion. Upon ignition, the pistons move only half as much as they do in reciprocal piston engine with a comparable displacement capacity, thus always enhancing the combustion because of the given symmetry. This is also evidenced by the calculations and animations prepared by the FEV with great effort. According to the FEV calculations, the mixture of air with the fuel is better during filling and emptying of the combustion chamber of the exhaust gases than in the reciprocating piston engine with its intake and exhaust valves located at the top because of the given optimized kinematics with the rotation of the entire inner spherical engine. The measurements during tests on the prototypes rendered definitive results. On the basis of our experience so far we are convinced that we can reach the values of modern reciprocating pistons and even exceed these and therefore be able to meet the requirements of future Euro standards.

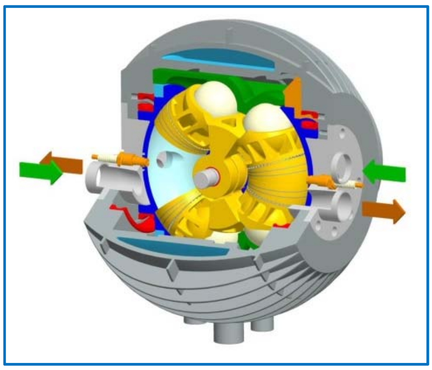


3. Life expectancy and production costs

The life expectancy of an engine depends on many factors. A major one is the number of components, especially the number of moving components. The Hüttlin-Kugelmotor® does not need any connecting rods, no cam shaft, no crank shaft, and no valves, so many of the moving components considerably influencing the life expectancy of an engine. All in all the Hüttlin-Kugelmotor® consists of only 63 components, but the reciprocating piston engine of 240 (see Appendix 2).

This low number of components also has a considerable effect on the engine production costs. Nowadays, a conventional engine is assembled in 3.5 to 5 hours. We can assume much shorter times, but with the complete assembly of a Hüttlin-Kugelmotor® taking half an hour less, this would mean a substantial saving with the following consequences: according to the OICA Organisation Internationale des Constructeurs d'Automobiles, in 2011 80.1 million vehicles were built worldwide, with 8,157,058 only by VW alone (see Appendix 3). Half an hour time savings per engine would mean saving more than 4 million production hours; in this time 1.359 million additional HKMs could be produced. Of course, not to be underestimated are the saving in grey energy (electricity and material) during production.

Regarding the complexity of the components and their production the answer can only be that the production of a conventional crank shaft is also not particularly easy, and that on the other hand a modern production facility needs only an appropriate programming to products almost any component required. So the production of the curved pistons is not really a challenge, as are the production of the curved elements and all other components of the Hüttlin-Kugelmotor®.



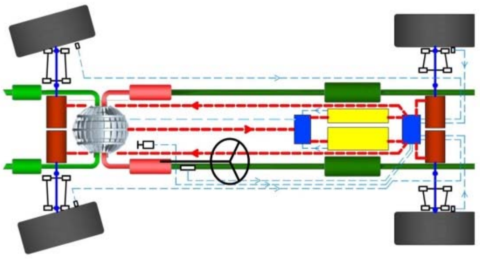
Another considerable factor influencing the life expectancy of an engine is the number of revolutions per minute, known as the speed. The Hüttlin-Kugelmotor®, a so-called slow or low speed runner, performs only half the revolutions to achieve the same result as a four cylinder reciprocal piston engine, which needs 720° or two full revolutions so that every cylinder runs through a full stroke cycle (intake, compression, ignition, exhaust), all at 180°. The HKM needs only one single revolution, so 360°, also all at 180°.

4. Hüttlin-Kugelmotor-Hybrid®

There is a valuable enhancement to the Hüttlin-Kugelmotor® as a pure combustion engine with a conventional drive using a drive shaft, namely the Hüttlin-Kugelmotor-Hybrid®, abbreviated to HKH, with further advantages over the existing technology. Each reciprocal piston engine can be converted to a hybrid by adding an extra electrical generator. In the HKH the generator is already integrated in the casing, which means that a lot of weight and space can be saved. In addition, this generator can be used as a starter for the engine, which means that no separate starter motor is required.

If we use the HKH as a range extender in an electrical vehicle for the production of electricity we have combined the advantages of electro-mobility and of the pure combustion engine:

- No need for a gearbox, cardan shaft, and the differential gears
- No need for a large and heavy battery
- The range is similar to a "normal" vehicle
- Refilling is a matter of minutes, and not hours of charging from a power source



Because the Hüttlin-Kugelmotor-Hybrid® not only produces electricity, but also heat, it can just as well be used as a CHP (combined heating and power system) to provide a building with electricity and heat for hot water and/or room heating.

5. Possible uses

The Hüttlin drive technology is very versatile and can be used as

- Motor and engine
- Range extender
- Compressor
- CHP
- Wind energy hybrid

Apart from the automobile industry a wide range of industries can become licensees of Innomat AG using this system:

Motorcycles and scooters
Electrically powered vehicles
Community vehicles
Construction machinery and vehicles
Boats and ships, from small craft to seagoing vessels
Tools for gardening and agriculture
Compressors for construction and industry
CHPs
Wind power
and many more.

For more information please visit www.innomot.org December 2013 / RL

Appendix 1 (Excerpt from the graduation paper by Lukas Keller and Jürg Studer)

7.1. Fuel saving

According to the German Federal Environmental Agency (UBA) a motor vehicle with an extra load of 100 kg consumes 0.7 litres of fuel more per 100 km.

An extra load of only 20 kg would mean an increase in fuel consumption of 0.14 litres per 100 km.

If a spherical engine is installed in the vehicle this would mean a weight reduction by 20 kg and consequently a fuel consumption reduction of 0.14 litres per 100 km.

If this also applies to the unloading of weight, this would mean a reduction of the fuel consumption of 0.7 litres per 100 km.

According to the Swiss Federal Road Traffic Agency there are 5.35 million motor vehicles in Switzerland, travelling a total distance of 56,697,000,000 km per year.

Appendix 2

Comparison of components

INNOMOT AG

2-chamber-Hüttlin-Kugelmotor®
(gasoline engine)

Components	Number
Aluminium housing, 2 parts	2
Aluminium lateral covers	2
Internal covers	2
Rotor, 2 parts	2
Rotor covers	2
Rotor bearings	2
Rotor gearing	1
Output shaft/screw	1
Bearings output shaft	2
Twin pistons	2
Piston centre bolt	1
Piston slide bearings	4
Piston guide balls	4
Piston bearing cup	4
Piston guide sleeves	4
60-2 timing wheel	1
Curve elements, 2 parts	2
Charge change seals	2
Seal springs	6
Lateral rotor seals	2
El. Frehs gas flaps	2
Fresh gas intake nozzles	2
Fuel injection jets	2
El. Charge air fan	1
Charge air radiator	1
Motor electronics	1
Exhaust gas lambda sensors	2
Exhaust gas manifolds	2
Exhaust gas nozzles	2
Number of components	**63**

Screws, seals and other small parts are not included.

Dr. h.c. Herbert Hüttlin

4-cylinder Otto-engine
(gasoline engine)

Components	Number
Cylinder block	1
Cylinder head	1
Valve cover	1
Crankshaft housing	1
Crankshaft	1
Crankshaft bearing blocks	5
Crankshaft main bearings	5
Flywheel	1
Piston rod bearing bolts	4
Piston rods	4
Individual pistons	4
Piston bolts	4
Cam followers	16
Hydraulic lifters	16
Valve spring bases	16
Valve springs	16
60-2 timing wheel	1
Charge change valves	16
Valve spring retainers	16
Valve keys	32
Valve shaft seals	16
El. Fresh gas flap	1
Fresh gas intake nozzles	4
Fuel injection jets	4
El. Charge air fan	1
Charge air radiator	1
Valve guides	16
Exhaust gas lambda sensor	1
Valve seat rings	16
Camshafts	2
Camshaft bearing blocks	10
Camshaft wheel	2
Crank shaft wheel	1
Idler pulleys	2
Tension pulley	1
Cam belt/camshaft drive chain	1
Number of components	**240**

Appendix 3

Organisation Internationale des Constructeurs d'Automobiles

Entwicklung der Fahrzeugproduktion nach Ländern

Aufgeführt sind die 25 Länder, in denen die größte Anzahl von Kraftfahrzeugen hergestellt wurden. Alle Angaben beziehen sich auf die Staaten in ihren heutigen Grenzen.

Rang (2011)	Land	1970	1980	1990	2000	2007	2008	2009	2010	2011	peak's year	peak's number
1.	China	87.166	222.288	509.242	2.069.069	8.882.456	9.299.180	13.790.994	18.264.761	18.418.876	2011	18.418.876
2.	Vereinigte Staaten	8.283.949	8.009.841	9.782.997	12.773.714	10.780.729	8.693.541	5.731.397	7.762.544	8.653.560	1999	13.024.978
3.	Japan	5.289.157	11.042.884	13.486.796	10.140.796	11.596.327	11.575.644	7.934.057	9.628.920	8.398.654	1990	13.486.796
4.	Deutschland	3.995.625	4.095.138	4.976.552	5.526.615	6.213.460	6.045.730	5.209.857	5.905.985	6.311.318	2011	6.311.318
5.	Südkorea	28.819	123.135	1.321.630	3.114.998	4.086.308	3.826.682	3.512.926	4.271.941	4.657.094		
6.	Indien	76.409	113.917	362.655	796.185	2.253.729	2.332.328	2.641.550	3.557.073	3.936.448		
7.	Brasilien	416.089	1.165.174	914.466	1.681.517	2.977.150	3.215.976	3.182.923	3.381.728	3.406.150		
8.	Mexiko	192.841	490.006	820.558	1.934.927	2.095.245	2.167.944	1.561.052	2.342.282	2.680.037		
9.	Spanien	539.132	1.181.659	2.053.350	3.032.874	2.889.703	2.541.644	2.170.078	2.387.900	2.353.682		
10.	Frankreich	2.750.086	3.378.433	3.768.993	3.348.351	3.015.854	2.568.978	2.047.658	2.229.421	2.294.889		
11.	Kanada	1.159.504	1.369.607	1.947.106	2.961.636	2.578.790	2.082.441	1.490.482	2.068.189	2.134.893		
12.	Russland	844.300	2.195.000	2.071.950	1.202.589	1.660.120	1.790.301	725.012	1.403.244	1.988.036		
13.	Iran	35.000	161.000	44.665	277.985	997.240	1.051.430	1.394.075	1.599.454	1.648.505		
14.	Thailand	22.055	73.347	304.843	411.721	1.287.346	1.393.742	999.378	1.644.513	1.478.460		
15.	Vereinigtes Königreich	2.098.498	1.312.914	1.565.957	1.813.894	1.750.253	1.649.515	1.090.139	1.393.463	1.463.999		
16.	Tschechien	169.920	233.112	242.000	455.492	938.648	946.567	983.243	1.076.384	1.199.834		
17.	Türkei	25.000	50.881	209.150	430.947	1.099.413	1.147.110	869.605	1.094.557	1.189.131		
18.	Indonesien	k.A.	k.A.	k.A.	292.710	411.638	600.628	464.816	702.508	837.948		
19.	Polen	113.087	417.834	347.975	504.972	792.703	945.959	878.998	869.474	837.132		
20.	Argentinien	219.599	281.793	99.639	339.632	544.647	597.086	512.924	716.540	828.771		
21.	Italien	1.854.252	1.610.287	2.120.850	1.738.315	1.284.312	1.023.774	843.239	838.186	790.348		
22.	Slowakei	0	0	0	181.333	571.071	575.776	461.340	561.933	639.763		
23.	Belgien	296.000	923.426	1.248.290	1.033.294	834.403	724.498	537.354	555.302	562.386		
24.	Malaysia	k.A.	104.227	191.580	282.830	441.661	530.810	489.269	567.715	540.050		
25.	Südafrika	297.573	404.766	334.779	357.364	534.490	562.965	373.923	472.049	532.545		

Entwicklung der Fahrzeugproduktion nach Herstellern

aktueller Rang	Änderung zum Vorjahr	Firmensitz	Konzern	Abgesetzte Fahrzeuge 2012	2011
1	▲		Toyota	10.104.424	8.050.181
2	▼		General Motors	9.285.425	9.146.340
3	▼		Volkswagen	9.254.742	8.157.058
4	—		Hyundai	7.126.413	6.616.858
5	—		Ford	5.595.483	4.873.450
6	—		Nissan	4.889.379	4.631.673
7	▲		Honda	4.110.857	2.909.016
8	▼		Peugeot	2.911.764	3.582.410
9	▲		Suzuki	2.893.602	2.725.899
10	▼		Renault	2.676.226	2.825.089
11	▲		Chrysler	2.371.427	2.004.514
12	▲		Daimler AG	2.195.152	1.528.008
13	▼		Fiat	2.127.295	2.399.825
14	▲		BMW	2.065.477	1.738.160
15	▲		SAIC	1.783.548	kA

Quelle:
http://de.wikipedia.org/wiki/Organisation_Internationale_des_Constructeurs_d%E2%80%99Automobiles_(OICA)