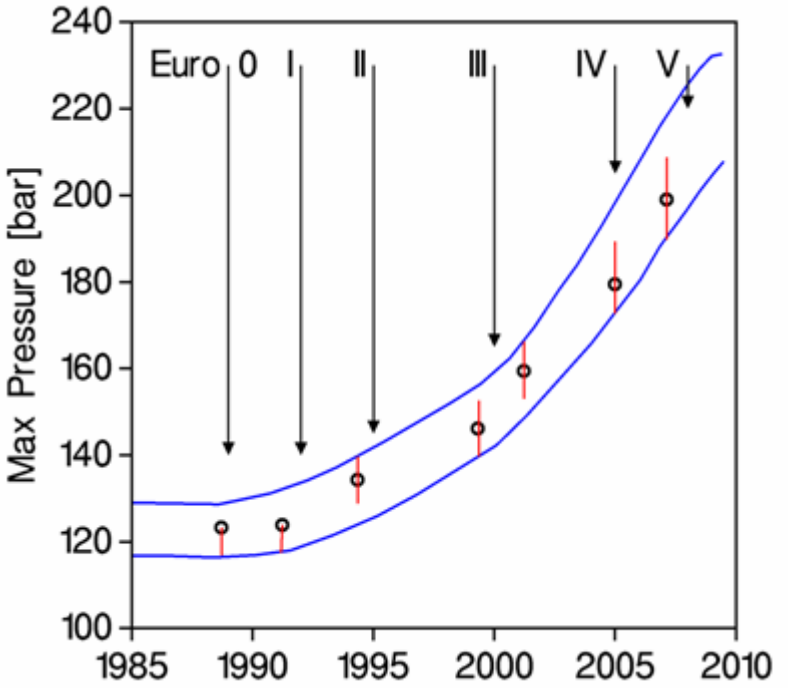
Oxygen activity measurement in cast iron as a method to improve ecological features of engines.

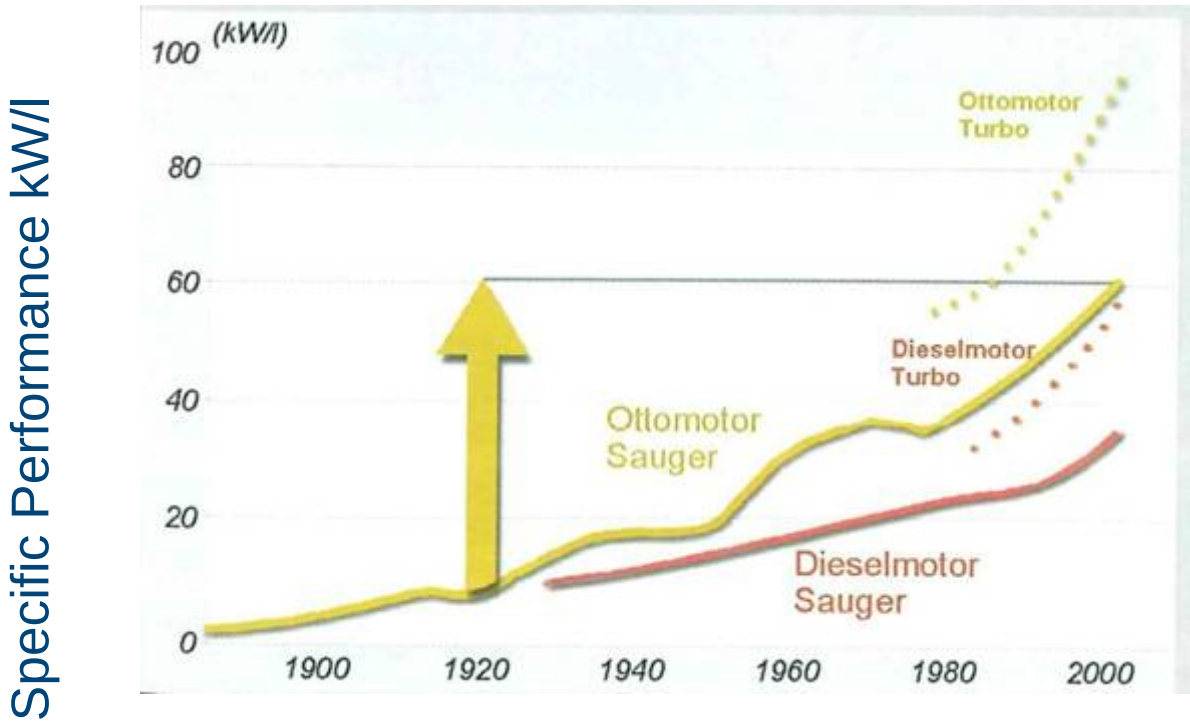
Frans Mampaey

Sirris Gent-Zwijnaarde



In order to meet the European exhaust standards (Euro 0-V on top), the combustion pressure in trucks must be raised to 200 bar [Vollrath 2003].

Increase of the specific performance in time



Vollrath 2003 konstruieren+giessen 2003 no. 2, 25-27

Specific Performance kW/l

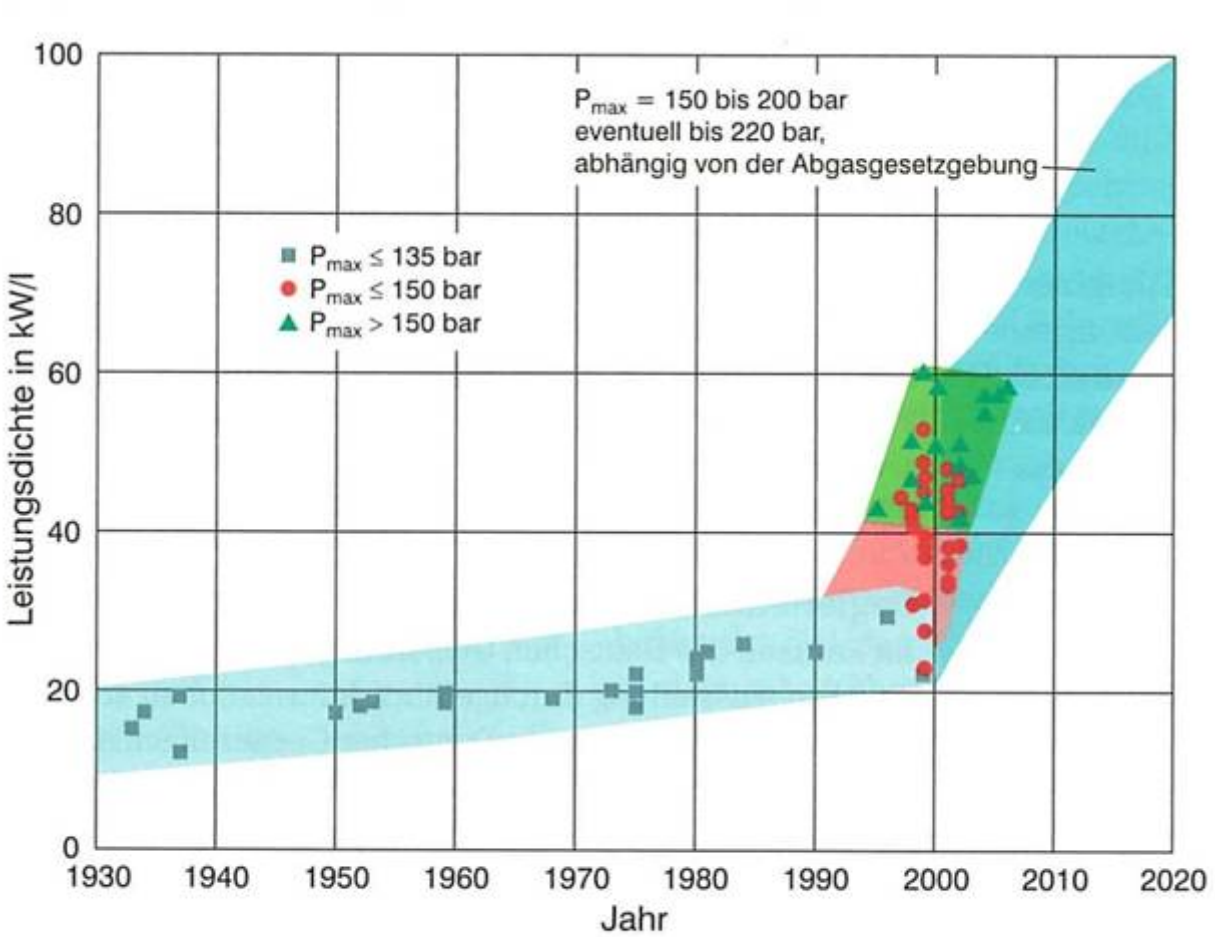


Bild 1: Anstieg des Spitzendrucks beim Pkw-Dieselmotor, insbesondere seit 1989

sirris
driving industry by technology

Reduce CO_2 emissions

The European car manufacturers (ACEA) agreed to reduce the CO2 emissions from 180g/km (2002) to 140g/km in 2008.

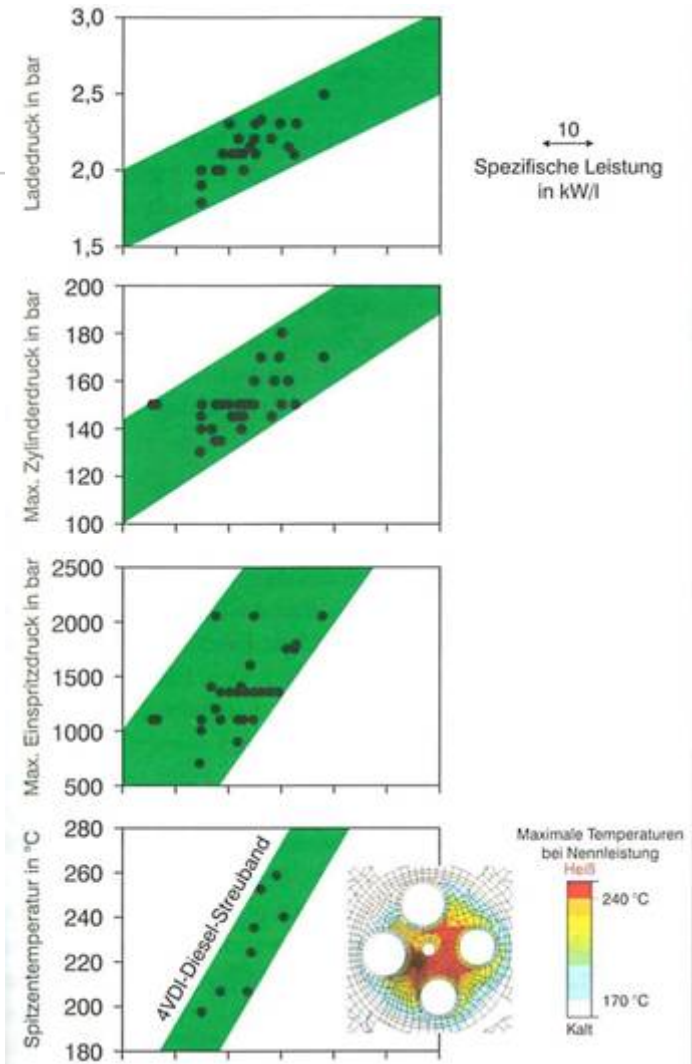
Three options

- less weight,
- better fuel economy
- raise of the diesel engine share.

The first two objectives can be influenced by cast engines.

The specific mass of a Diesel engine has decreased from about 2,5 kg/kW (1990) to about 1,30 kg/kW in 2002.

Max Pressure
bar



An improvement of the fuel economy requires higher peak pressures during combustion

Increase the internal combustion pressure

raises of the specific performance

Increasing the peak pressure with 10 bar

raises

the specific performance of the engine with 6,7 kW / liter engine cylinder capacity.

Specific Performance kW/l

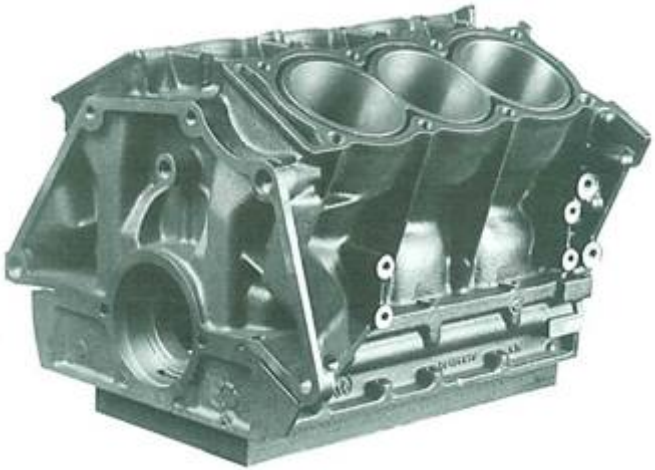
Trends

Future engines will be characterized by

- an increase of the specific performance (Downsizing) and
- a higher peak combustion pressure for diesel engines [Pischinger 2003].

Downsizing can reduce the fuel consumption of a high middle class car by about 25 percent.

Opel Calibra 1994



First motor in Compacted Graphite Cast Iron

Original motor Lamellar graphite cast iron

Typ	Cylinder Wall thickness
1,6 l, 4-Zylinder-Reihenmotor	13,0 mm
2,0 l, 4-Zylinder-Reihenmotor	7,0 mm
2,5 l, 6-Zylinder-V-Motor, Standardversion	6,0 mm
2,5 l, 6-Zylinder-V-Motor, Rennversion	4,0 mm

konstruieren+giessen 1994 nr 4 p 46

Reducing cylinder wall thickness

lower mass, same external motor size

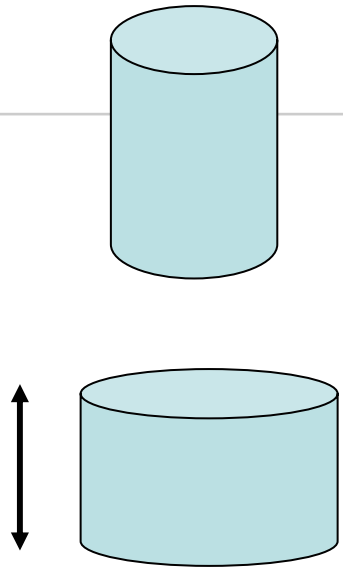
cylinder diameter 87 → 89 mm

for the same cylinder volume →

smaller displacement of the piston

less friction → more power

less wear



Good experience with racing version → also CGI motor in the standard version

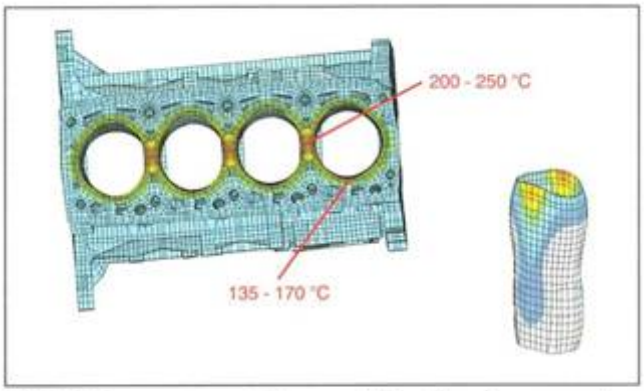
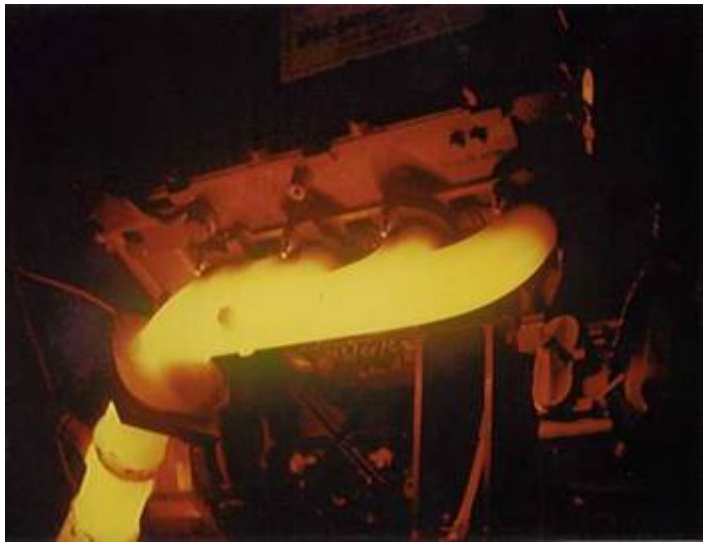


Bild 7. Temperaturverteilung und Bauteilverformung eines Motorblocks

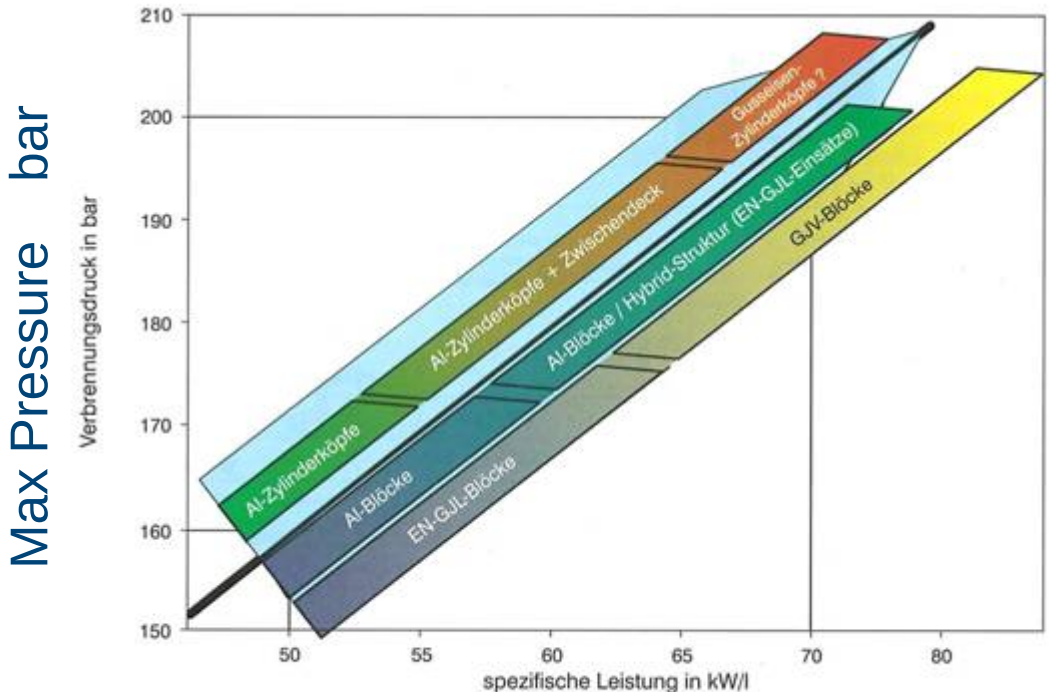


950 °C

Smaller wall thickness but the same stiffness

E-modulus 130 GPa (LG) → 160 GPa (CG)

The current aluminium alloys and lamellar graphite cast iron have reached their mechanical limits.



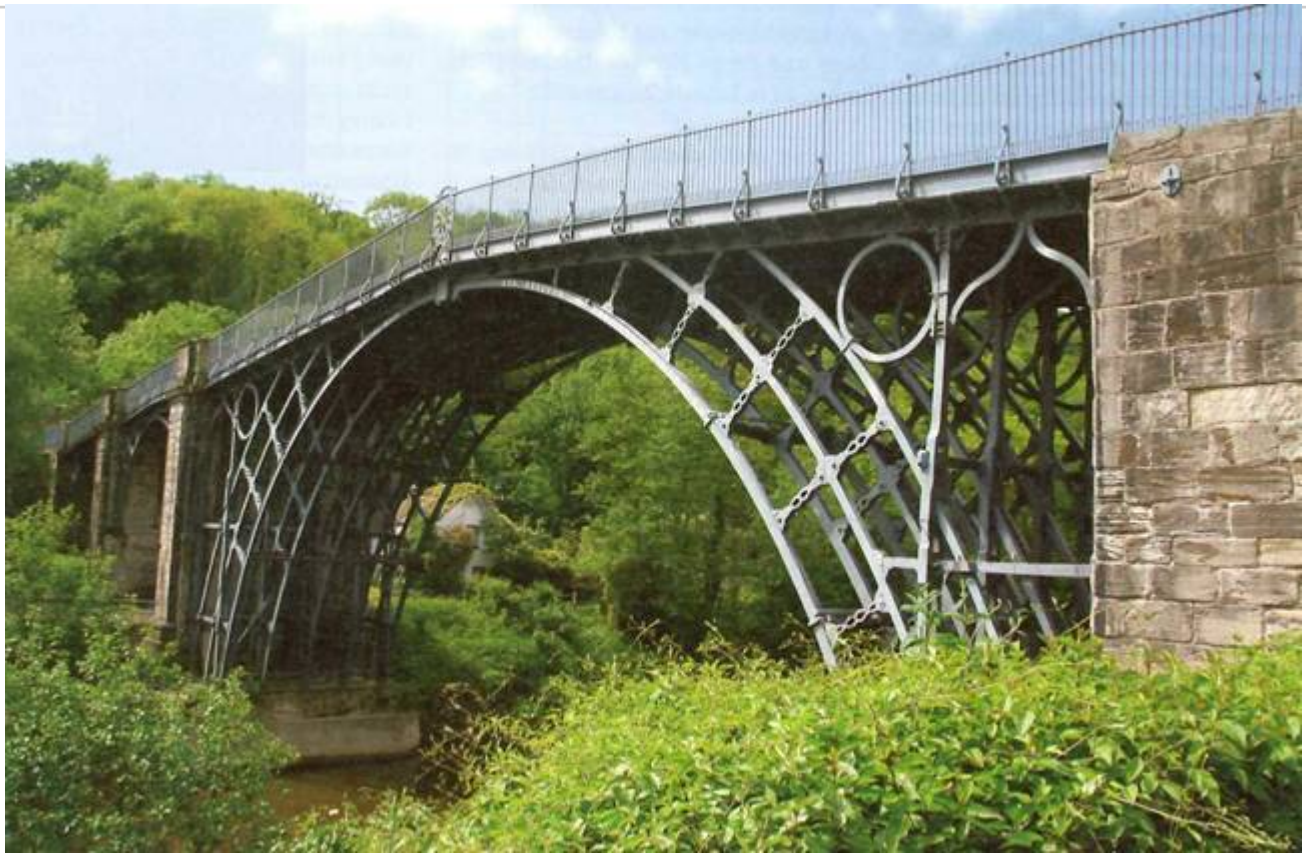
Specific Performance kW/l

With higher combustion pressure, also the internal cylinder temperature goes up from 200⌖C to 260⌖C.

Aluminium alloys considerably loose strength above 200⌖C. Cast iron room temperature mechanical properties remain the same up to 400⌖C.

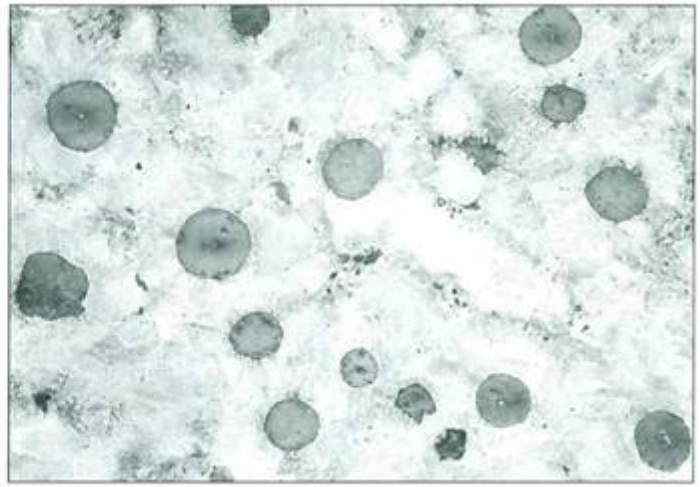
sirris
driving industry by technology

Cast Iron



First bridge in cast iron on river Severn (UK) 1781

Cast iron



1948 Nodular cast iron

Strength	250 MPa	800 MPa
Production	42 M ton	21 M ton
Al- alloys	12 M ton	

sirris
driving industry by technology

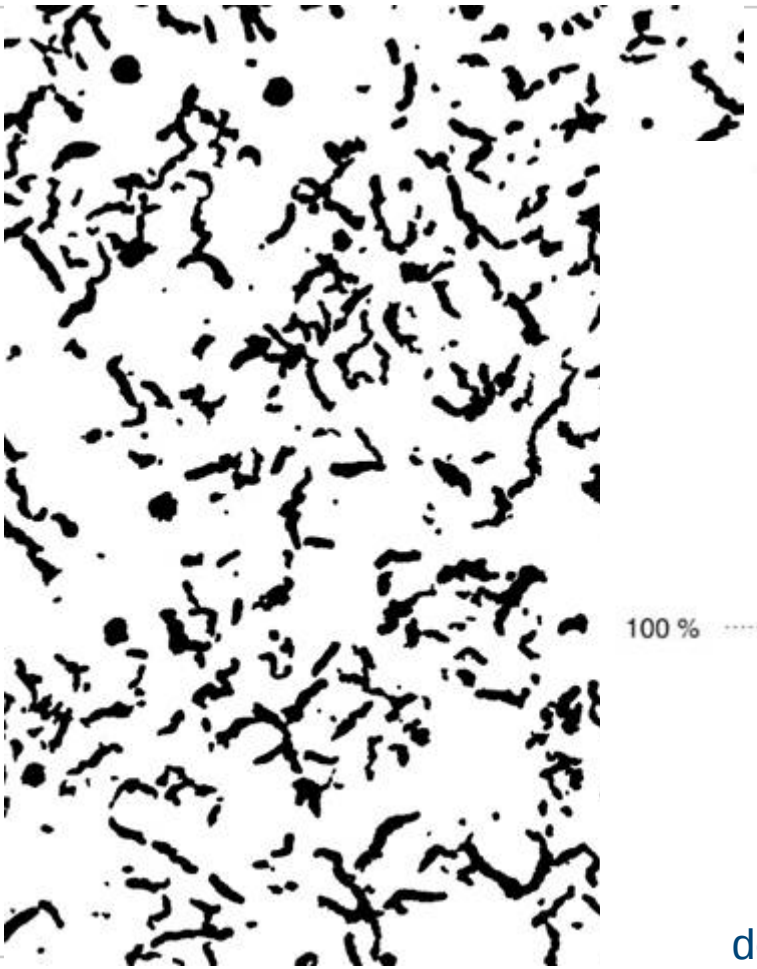
A new material

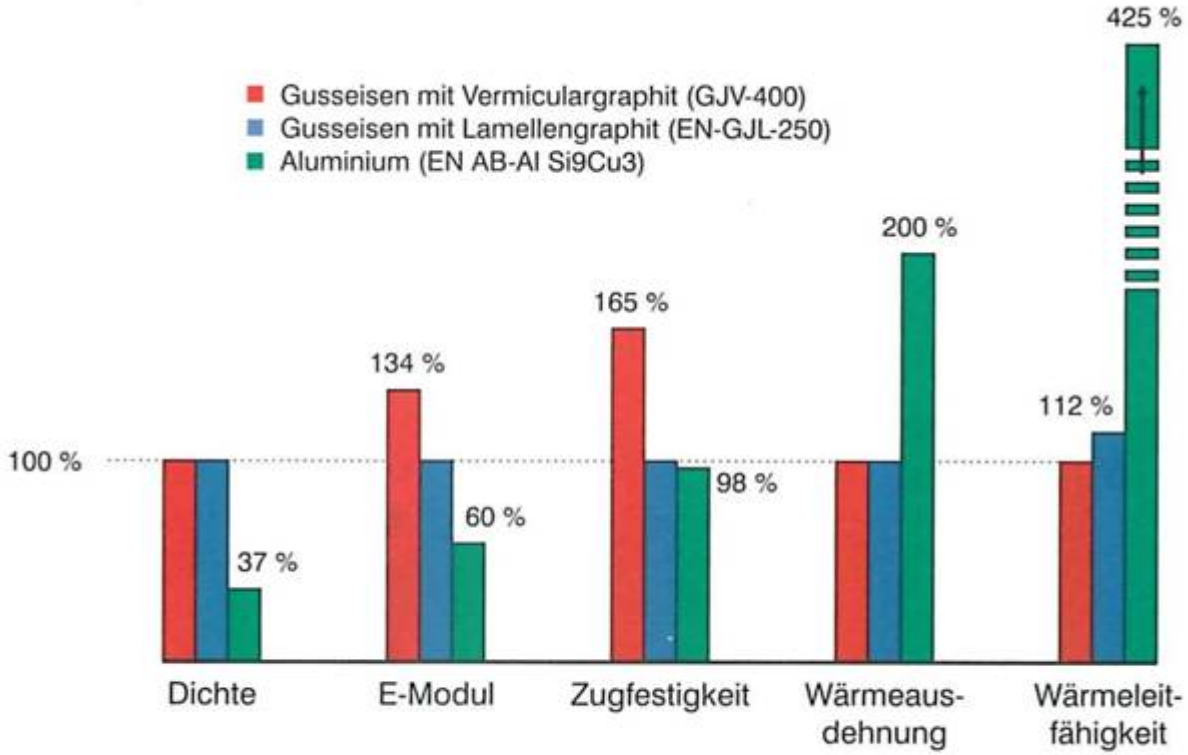
Higher strength

Good thermal conductivity

→ excellent material for new engines

But difficult to produce





density

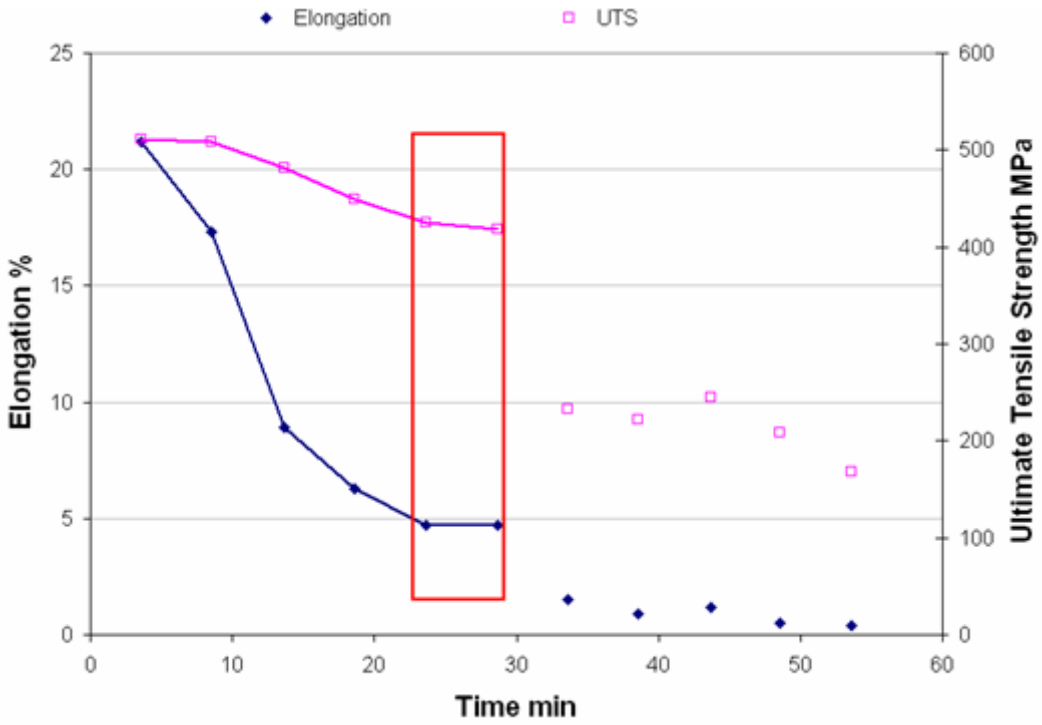
Strength

Thermal conduct.

sirris

driving industry by technology

A new production control tool
Oxygen activity measurement



← Thermal conductivity loss

→ Strength loss

Higher strength

Good thermal conductivity

→ excellent material for new engines

But difficult to produce

A new production control tool
Oxygen activity measurement
Heraeus Electro-Nite Belgium