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Gas and Gasoline Engines to 1900

1880-1900

- Quick improvement in economy and reliability.
  - Liquid fuel $\Rightarrow$ Mobile applications
  - Refined ignition (electrical)
  - Refined carburetion
  - Multiple cylinders
  - New fuels
- New applications

Daimler and Maybach

- Left Deutz, 1882, to work on an automobile
- 500 kg per hp @ 200 rpm not enough
  - Ignition a problem @ 600-800 rpm
    - Idea; Ignite at hot piston, cooling on lower cylinder part
    - Reality; Hot tube igniter
    - Even though open flame, more reliable then electric spark
  - Correct air-gasoline mixture in a compact container
    - Heated air to improve vaporization
- Standuhr, (Upright clock)
  - Put in motorcycle
  - 0.5 hp @ 600 rpm, 200 kg/hp
  - Special exhaust actuation (figure 12-8)
  - Third valve to reduce residual gas, Otto patent/efficiency
- First Daimler automobile 1.1 hp water-cooled Standuhr
- Sold both engine and automobile
- Engine applications; the auto, small boats, fire engine pumpers, street cars (trams) and industrial locomotives

Daimler and Maybach cont'd

- 1890: Vee engine, used in the first Peugeot
- British law until 1893: Person must walk fifteen yards in front of self-propelled vehicle
- Maybach inventions:
  - Four cylinder in-line engine 5 hp @ 620 rpm, 30 kg/hp
  - Tubular cooling pipe $\Rightarrow$ Radiator
  - Carburetor that sprayed fuel into an air stream
  - Two cylinder in-line "Phönix" engine. Single block cast, water cooled. 4.2 hp @ 800 rpm, 20 kg/hp
    - Used to race 1183 km in 49 h!!
- Modern cars:
  - Saab 9-3 SportCombi Biopower, XWD, AT, 8 kg/hp
  - Ferrari Enzo, 2.3 kg/hp
  - Bugatti Veyron, 1.9 kg/hp
  - Ariel Atom V8, 1.1 kg/hp

Karl Benz

- Built cars, engines were a part of the system
- Largest car producer of the 19th century (2000 units)
  - Toyota produced 6,157,038 units in 2005
- First Benz car:
  - Horizontal plane flywheel to not affect steering
  - 0.7 hp @ 300 rpm, 137 kg/hp
  - Gasoline was heated, using exhaust, to aid vaporization
  - Electric ignition (fig 12-19), battery limited driving range
  - Evaporative water cooling
  - 15 l/100km gasoline, 150 l/100km water
  - Belt drivetrain
- Engines went up to 14 hp @ 900 rpm
  - "oversquare" 135 mm bore, 130 mm stroke
- Daimler and Benz competed a lot on the race track
- Daimler and Benz joined together in 1926 (after Daimler's death)

Siegfried Marcus

- Austrian, most known for his automobile
- Invented the low tension magneto and wick-type carburetor before Daimler and Benz
- Had problems with the Otto patent

Electric Ignition

- "Make and break" or "jump spark" (with make and break in the circuit)
  - Use the piston as movable electrode (Regan 1889)
- Battery or low tension magneto
  - High tension magneto through extra transformer (Paul Winand 1887)
  - Inspired Robert Bosch who made de facto standard in 1902
- By 1900 the hot tube was obsolete
- Simplex igniter:
  - Spark plug sealed off in a chamber to avoid fouling
  - Residual gas cleaning of chamber
- Simplex engine:
  - Reliable, "with ordinary attention it will work for more than a year without any repairs"
  - 600 hp @ 90 rpm
  - Gasoline in carburetor were heated with water instead of exhaust to avoid deposits (engines < 6 hp)

Engine Speed Control

- Especially electric power generation required constant speed under large load variations
- Runaway was not a problem with early low speed engines
- Regulate the gas valve to pump less "power" into the piston
  - Worked well for steam engines
  - ICE's got problem with the lean limit
- "Hit and miss". Turn gas supply off completely to not waste fuel
  - Large flywheels to make smooth, still not sufficient for electric generation
  - First stroke with gas more powerful due the scavenging
  - Alternative: Turn off the spark instead of gas
    - Simple implementation
    - Wastes fuel
- Implement with centrifugal governor or pendulum governor (fig 12-30)
- Control the exhaust valve

Some Concepts

- Compound Gas Engines:
  - Achieved longer expansion through a secondary piston that could expand in addition to the primary
  - Complexity cost vs. cheap fuel was a problem for this type of engine
- Hamiltons's Pressure Scavenging
  - Air pump cylinder to scavenge during exhaust of power cylinder
  - 2000 hp @ 90 rpm
  - "... they be stopped for less than ten hours once every two weeks"
  - Scavenging improved fuel consumption by 5%
  - No residuals (less heat?) made higher compression possible, which was a greater efficiency gain
- Bánki High Compression Engine
  - Sprayed water in air-fuel mix to cool down inside cylinder
  - Made high compression ratios possible
  - Brake thermal efficiency(?) of 28%

Gas Production

- Illuminating gas became expensive as the power demand increased
- New refining methods gave new cheaper fuels (flame color was no longer important)
- Natural gas available locally in USA
- (Blast furnace) Gas could be acquired as a by product from iron production

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