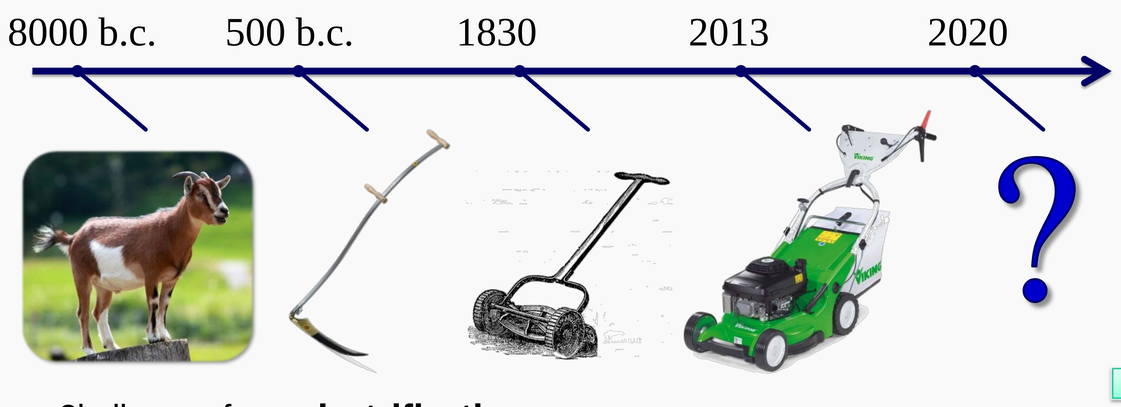
Investigation of a Standard Lawn Mower Engine in Real World Operation

Motivation for this Lawn Mower Investigations

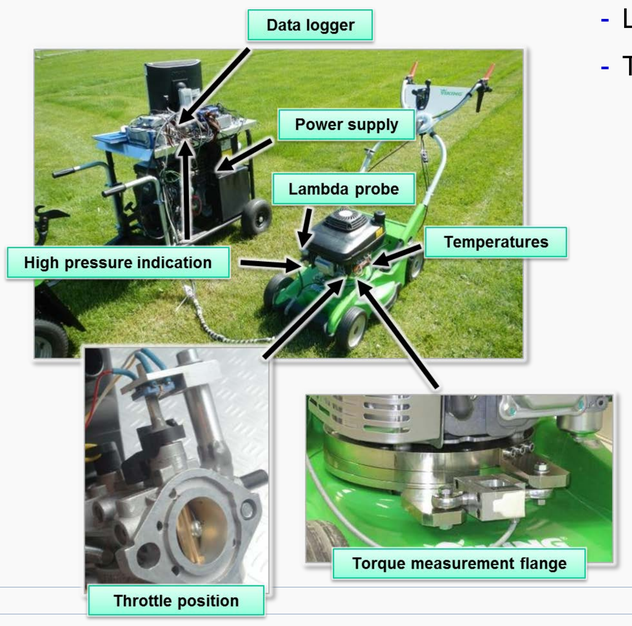
- **Evolution of mowing** – a continuous development

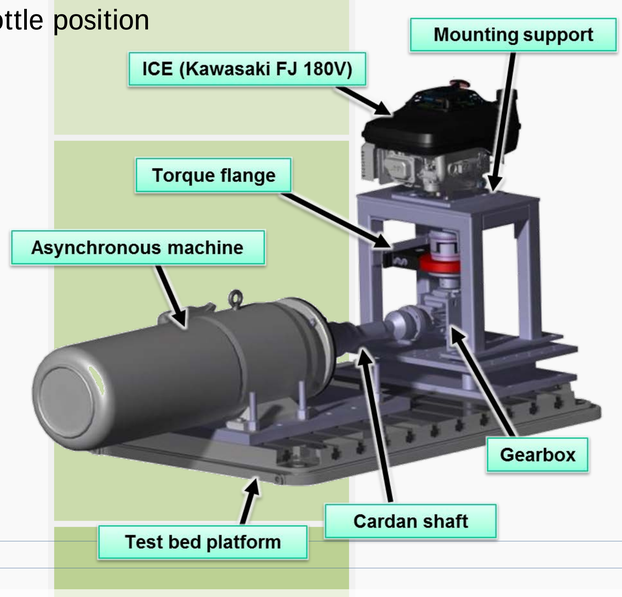


- Challenges from **electrification**
- Possible **product improvement** potential in
  - Performance
  - Efficiency
  - Exhaust and noise emissions
- Illustration of **present situation** as basis for **future development**

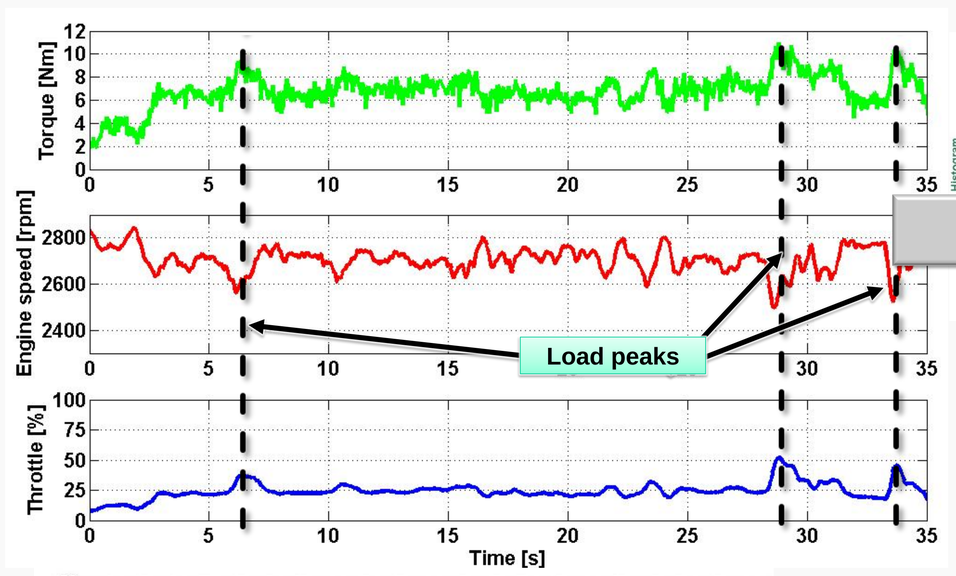
Real World Tests & Engine Test Bench Setup

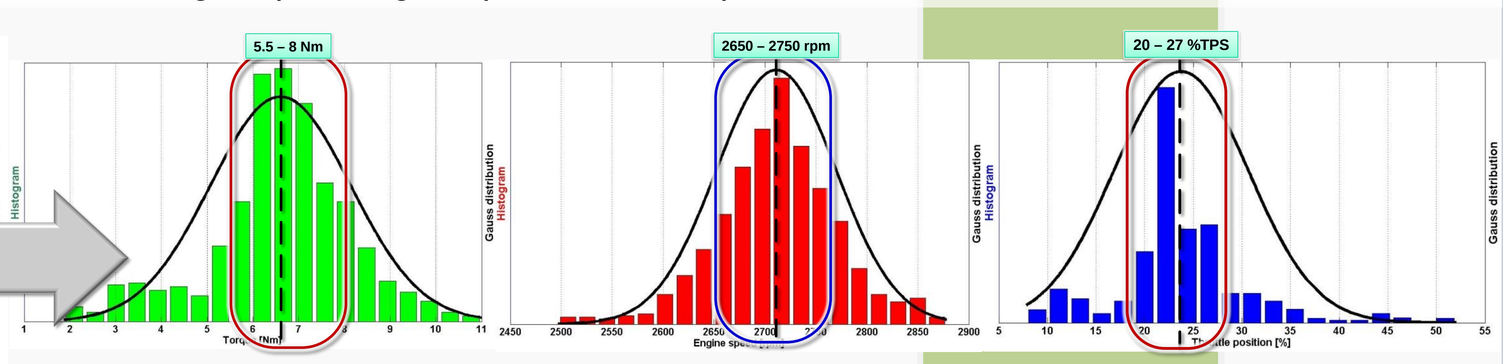
- **Goals**
  - Engine **load collective**
  - **Throttle control**
  - Comprehensive **engine analysis**
- **Data acquisition**
  - Mobile data logger
  - Mobile power supply
  - Torque measurement
  - Lambda value
  - Throttle position
  - High pressure indication
  - Engine temperatures
  - Engine-out emissions
  - Fuel mass flow





Mowing operation data analysis **Sequence** of: - Mowing torque - Engine speed - Throttle position - Centre of combustion - Lambda value

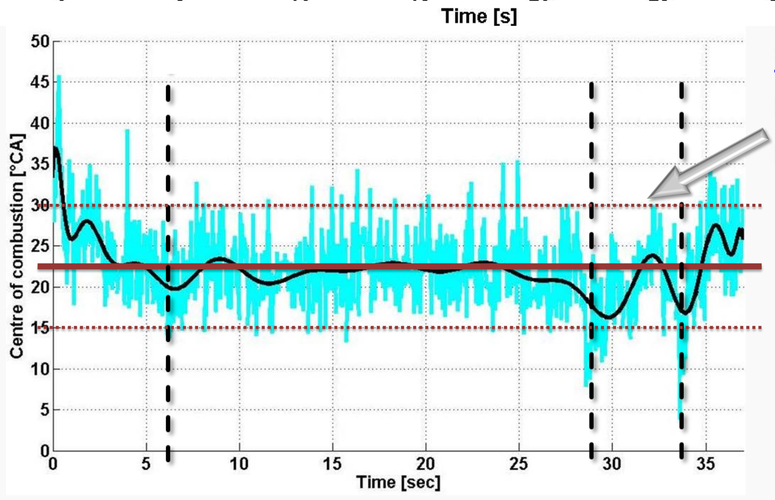




Mowing torque
Mean value: **6.8 Nm**
Main operation: ~ **5.5 – 8 Nm**

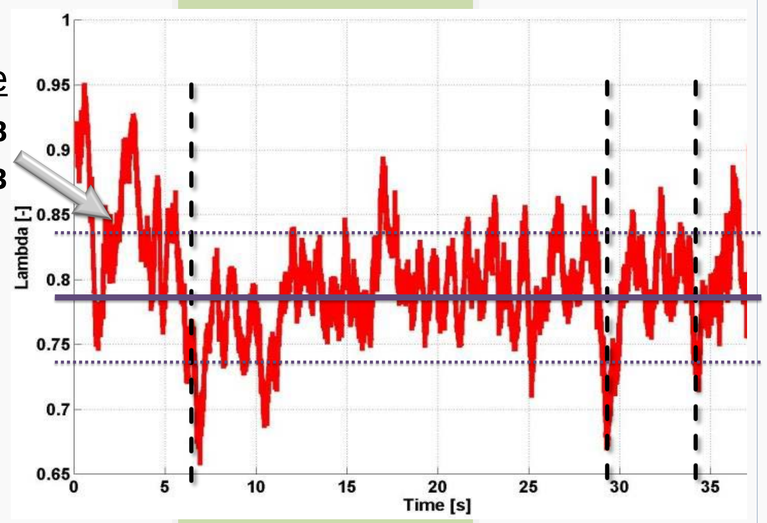
Engine Speed
Mean value: **2700 rpm**
Main operation: ~ **2650 – 2750 rpm**

Throttle position
Mean value: **23 %TPS**
Main operation: ~ **20 – 27 %TPS**



Centre of combustion
Mean value: **22.5 °CA**
Main operation: ~ **15 – 30°CA**

Lambda value
Mean value: **0.78**
Main operation: ~ **0.73 – 0.83**

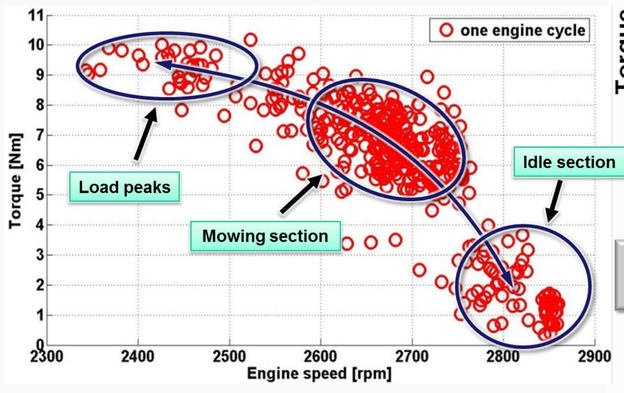


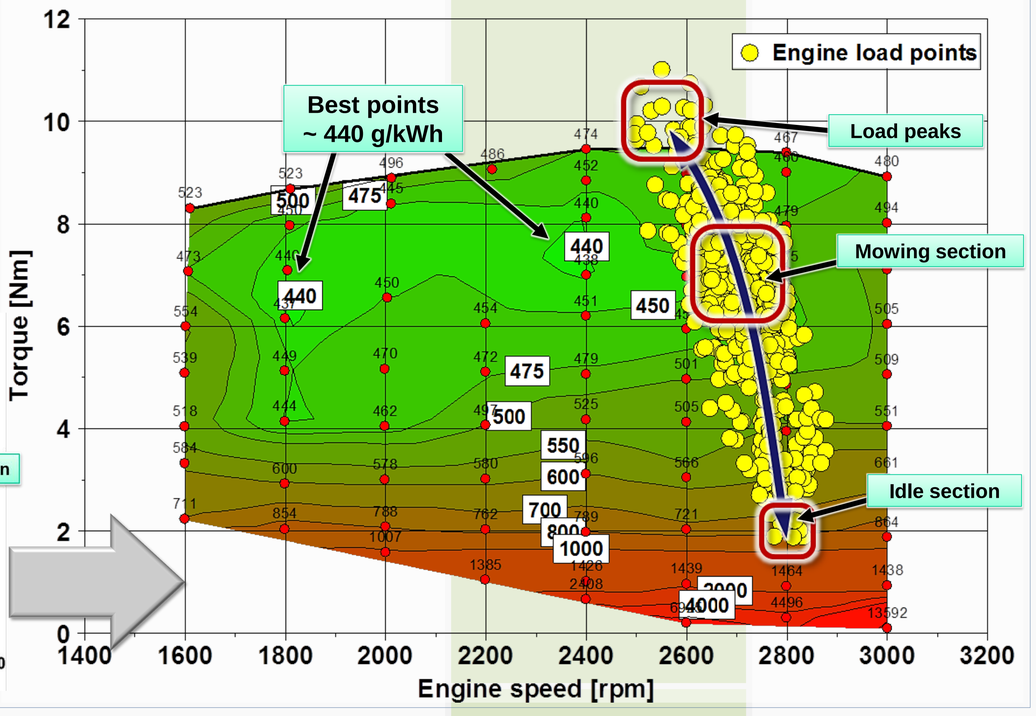
The **most frequently load points** while mowing are in between 2600 – 2750rpm, 6 – 8Nm and 20 – 25%TPS. **Load peaks** reach to 2400rpm, 11Nm, 75%TPS. **High idle speed** is located at about 2750rpm, 3Nm, 12%TPS and **standard idle** at around 2800rpm, 1.8Nm, 7%TPS. In general the **carburettor characteristic** is on the **rich** side. At **transient operation** the lambda values are alternating strongly and the **load enrichment** is clearly depicted. Fast load shifts result in an intense enrichment of the mixture. The **centre of combustion** during mowing operation in general is **rather late**. The non-variable ignition system causes the 50% MFB point to move with engine speed and engine load.

BSFC **engine map** vs. real world **load point distribution**

- BSFC value: The **fuel consumption** is described in relation to the **engine output**.
  Best point: **~ 440 g/kWh** Main operation: **~ 440 – 550 g/kWh**
- Load point distribution: The **engine torque** is printed over **engine speed** with each circle representing the average value of **one engine cycle**.

The **engine analysis** shows that the engine **setting for EU markets** with idle speed at **2800 rpm** is not ideal. **Originally** the engine is designed for idle speed at **3200 rpm**, consequently a mowing speed of about 3100 rpm. At this setting the **power output** is much **higher** as is the **rotational inertial** energy. Furthermore the **cutting load** is located clearly **above** the speed of the **highest torque value**. Thus the persistent **high loads** are **countervailed** through the engine torque reserves. At the **European** setting the engine has **not enough** torque **compensation ability**. The **load demands** for the first transient **load points**, which are **overshooting** the stationary full load line are **covered** through the inertia of the engine and the cutting blade; if the **load persist** the **engine stalls**.





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