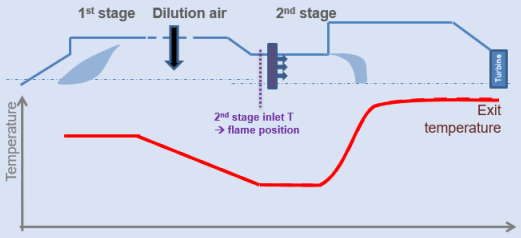
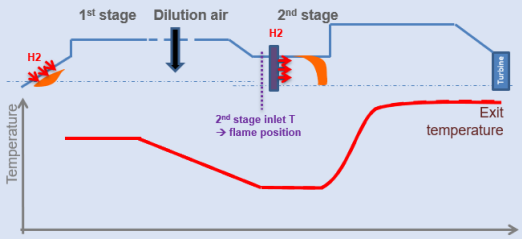
Constant Pressure Sequential Combustion (CPSC): fuel flexibility

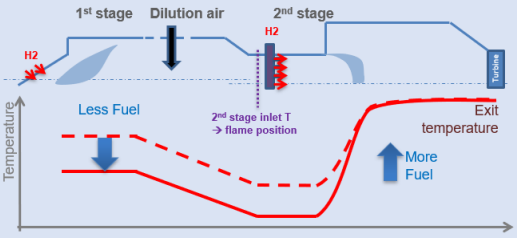
The sequential combustion system is composed of two combustion stages in series. A first (upstream) stage is stabilised by flame propagation in a swirling flow, while the second (downstream) stage is stabilized by self-ignition.



Turbulent flame speed, primarily driven by equivalence ratio and fuel composition, defines the flame location of the first stage, while the second stage inlet temperature together with the fuel composition constitutes the main factor defining the flame location of the second stage.
In case of a major change in fuel reactivity, e.g. replacing natural gas with a hydrogen-based fuel, flames tend to flashback due to their faster flame propagation speed and shorter self-ignition time.



In a CPSC system however the effect of the higher fuel reactivity can be compensated by adjusting the fuel split between the first and the second stage.
In particular, if fuel reactivity increases:



1. Less fuel is injected in the first stage
2. → the lower equivalence ratio in the first stage brings the turbulent flame speed at optimum values for best performance of the first stage (see also Fig. 1).
3. → the lower first-stage flame temperature produces a lower inlet temperature in the second-stage
4. → the lower second-stage inlet temperature brings the self-ignition time at optimum values for the second-stage (see also Fig. 2)
5. → the second-stage flame is at its design location ensuring best combustor performance
6. → more fuel is injected in the second-stage recovering the power loss of the first stage. Note that higher equivalence ratio in the second stage has minimal impact on self-ignition time, thus not compromising the beneficial effect of the lower inlet temperature on the flame location.

First stage: flame propagation

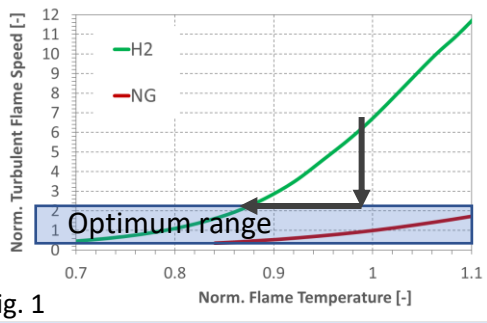


Fig. 1

Second stage: self-ignition

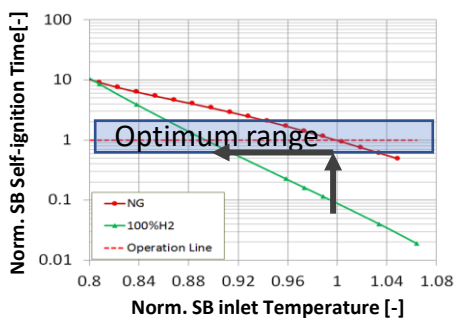


Fig. 2