Analysis of the chemical kinetics of different biomass syngas compositions and tar concentration on the combustion timing of an HCCI engine.

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1 Context and motivation

Inserted in the proposal of an energy transition to reduce greenhouse gas emissions, biomass appears as one of the most reliable and easily integrated into the current distribution system, especially for distributed generation. One of the main barriers to the further development of this technology is the costly cleaning and cooling of the syngas to internal combustion engines.

According to [1] the cleaning process can represent up to a third of the total investment of a new unit besides the added complexity and difficulty of maintenance (+5% of the investment annually [1]). The currently available engine technology on the market indeed requires a pre-treatment of the syngas which reduces the competitiveness of this cogeneration technology.

However, studies performed by this group showed that the HCCI (Homogeneous-Charge Compression-Ignition) technology can deal with un-cooled and untreated syngas [2]. Unlike the existing technology, the HCCI has a unique capability of admitting syngas at temperatures higher than the tar dew point.

HCCI technology for the use of uncooled syngas has already been demonstrated by the partners [2], [3], but despite the promising initial results, the engine has not been optimized and still need to be further investigated concerning longer operation periods. The previous studies were performed in a two-stage downdraft gasifier and the current set-up will consist of a single-stage therefore different tar species are expected to be found in the syngas.

2 Methodology

A previously developed 0-Dimensional model [4] was used to estimate the ignition-timing under HCCI conditions. The simulations were first validated against the experimental results previously published by the group in [2] and [3]. The kinetic model proposed by [5] which contains 413 species was considered. It includes a wide range of hydrocarbons that match with the existing tar species in the literature. The selection of tar species was considered upon the report given by the gasifier manufacturer.

3 Preliminary Results and Prospects:

The preliminary results shown in Figure 1 indicates a converging effect in the ignition-timing caused by a higher concentration of the tar species. The desire operation interval was highlighted. The effect of the presence of tar species was more significant than the variability reported by the gasifier manufacturer.

A more in-depth analysis of the possible tar species and how its concentration would affect the ignition timing is proposed for the next steps of the analysis. It is desired to propose a robust design of the engine that could cope with variations in syngas composition, tar species, and different intake temperatures.

The later output of the project consists of research results developing the state-of-the-art HCCI using uncooled syngas. It will be validated by a demonstrator optimizing power density, minimizing unburnt

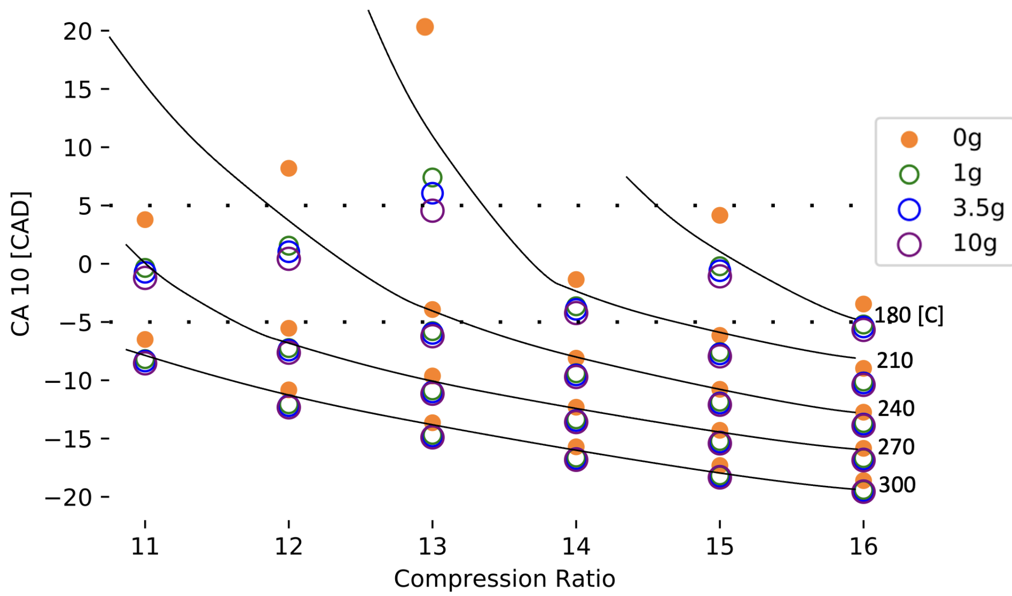

Figure 1: Effect of tars quantity in the ignition timing as a function of intake temperature and compression ratio. The maximum compression ratio is shown to 15 for a tar dew point >= 180°.

fuel, and having a charge control and cold ignition capabilities which are topics not yet addressed in the literature.

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