



Biorefinery runs in Sweden

ABOWE pilot plant tests at Hagby chicken farm

Erik Dahlquist, Patrik Klintenberg, Sebastian Schwede, Yuying Li

Mälardalen University, Future Energy





Pilot plant A tests at Hagby chicken farm





Substrate

- The main substrate was the slaughtery material from an ecological chicken farm at Hagby, Enköping (40km of Västerås).
- There was too little glucose formed for 2,3-butanediol production. Waste apples were added in some runs to recover this lacking easily available (for the microbes) carbohydrates.
- Produced high concentrates of valeric (pentanoic) acid. This is a valuable aroma substance, which can be converted to butadiene as like the 2,3-butanediol. It was later obtained from the slaughterhouse and chicken farm waste mix also without the apples addition.
- It was difficult to preserve the hydrolyzed waste - the hydrocarbons were partially degrading into miscellaneous products. Cooling after slaughtering was inadequate.
- However, the initial mixture of amino acids and lipids was successfully converted into a mixture of organic acids and alcohols.

The runs - Substrate

At Hagby bird farm August-October

Substrates- slaughter house wastes, chicken manure, straw, sawdust

Protein and fat rich material





- As the glucose limitation prevented the 2,3-butanediol formation, alternate products were searched for. Partially different outcomes than in Poland and Finland, were found.
- They included other valuable substances such as valeric acid, amyl substances and pentanol.
- We first got relatively high H₂ production as like in other countries for about two days, which then decreased. Was hydrogen bound to amino acids, as there was much protein in the slaughter waste?
- NH₄ increased instead, and could possibly get collected as precipitate for fertilization.



Microbiology

- Bacteria of the genres **Clostridium** and **Klebsiella** were utilized, the latter of which was not effective for 2,3-butanediol production due to the glucose limitation of the raw material, after the hydrolysis more amino acids and lipids containing were obtained.
- Clostridium acetobutylicum and Clostridium butyricum were brought from Finland. They produced organic acids like acetate, propionate and butyrate.
- No lactate was produced. Waste hygienization probably eliminated the lactic acid bacteria, such as *Lactobacillus* sp.
- What was positive was that the proteins and fats could be utilized quickly by the *Clostridium*, producing acids, which could have been converted to alcohols.
- Some of acetate and propionate was merged into valeriate or valerian (valeric/ pentanoic acid). It's price is 2-3 times that of 2,3-butanediol.

Indicators – H₂ often a byproduct of other reactions

RUN2 first and second line shows adding of potato flour, third line adding of sugar.

RUN3 first line shows adding of apples, second line adding of apples.





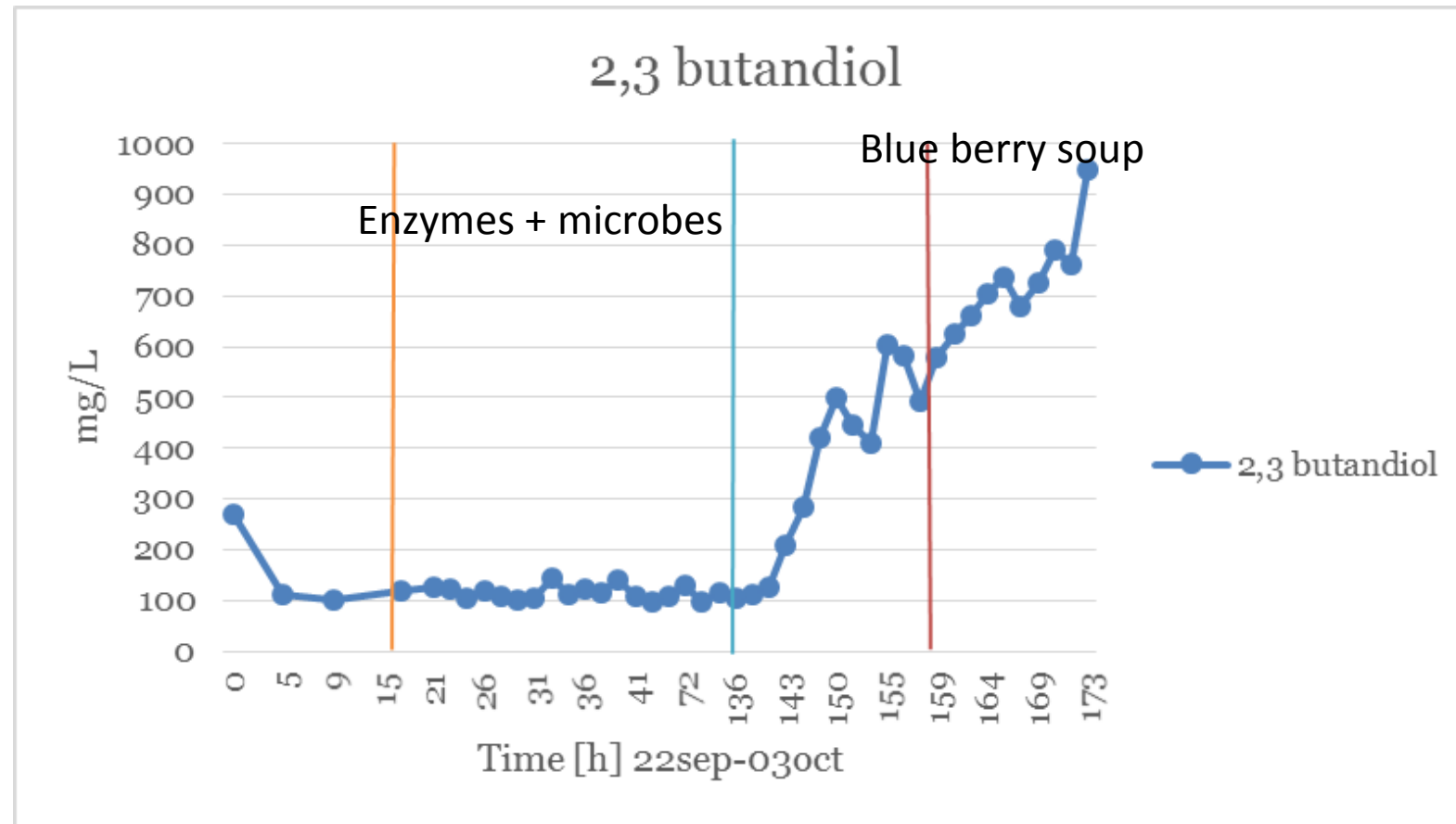
Run4

Substrate: manure, sawdust, intestines + blueberry soup at the end of the run

Enzymes: Optimash, Viscamyl, Glucostar

Microorganisms: Clostridium butyricum, Clostridium acetobutyricum

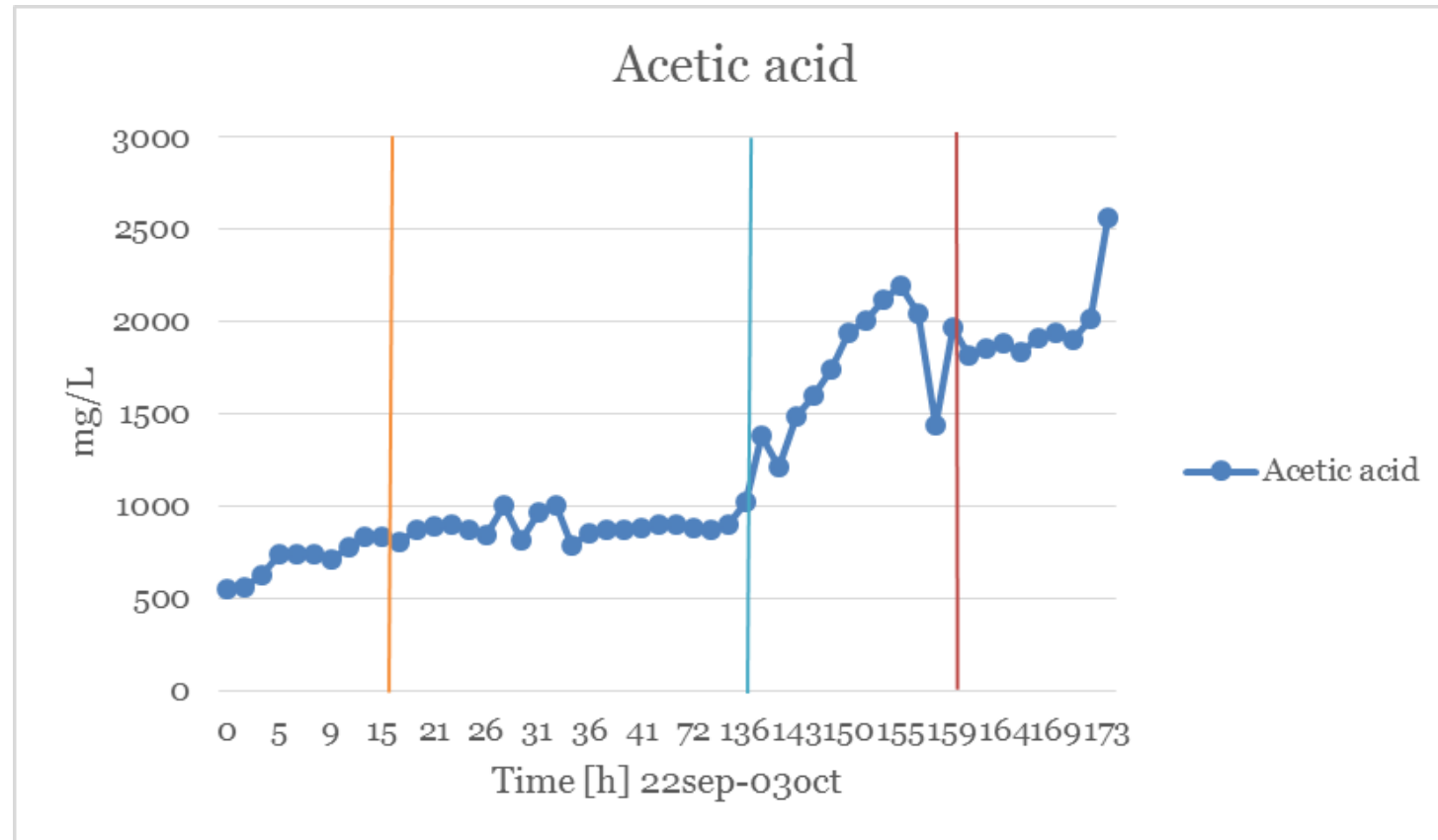
Hydrolysis in two steps- manure and sawdust in first step



2,3 Butandiol produced during the fourth run

The first 2 lines shows addition of enzymes and microbes and the third line shows the time for addition of blueberry soup

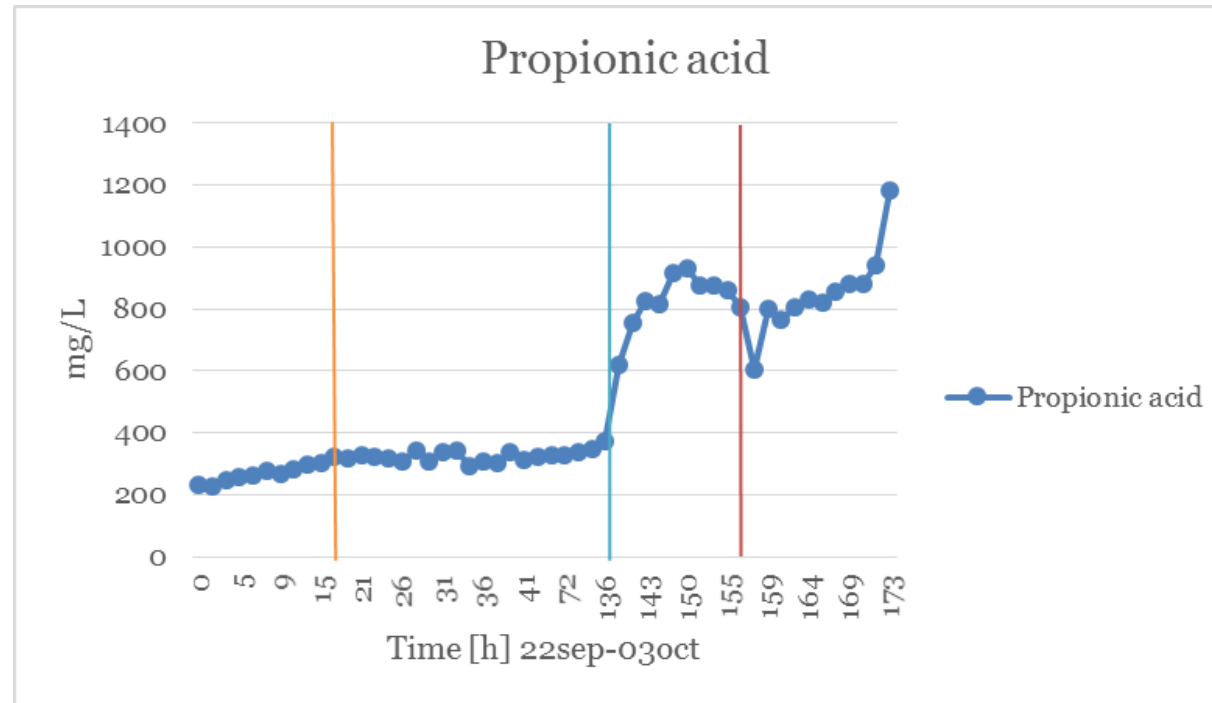
Acetic acid



Acetic acid produced during the fourth run

The first 2 lines shows addition of enzymes and microbes and the third line shows the time for addition of blueberry soup

Propionic acid



Propionic acid produced during the fourth run

The first 2 lines shows addition of enzymes and microbes and the third line shows the time for addition of blueberry soup



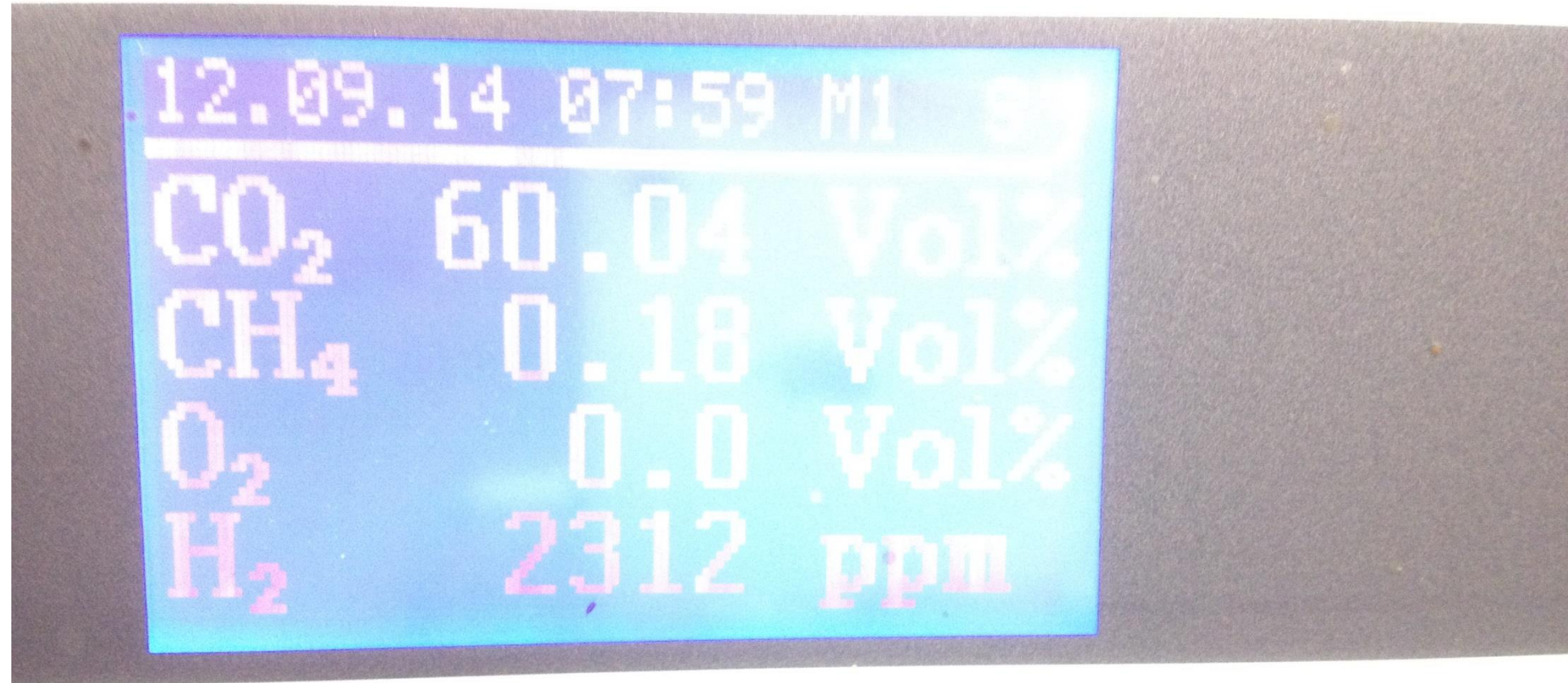
Thank you for listening

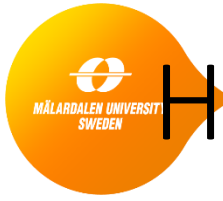
- Questions?



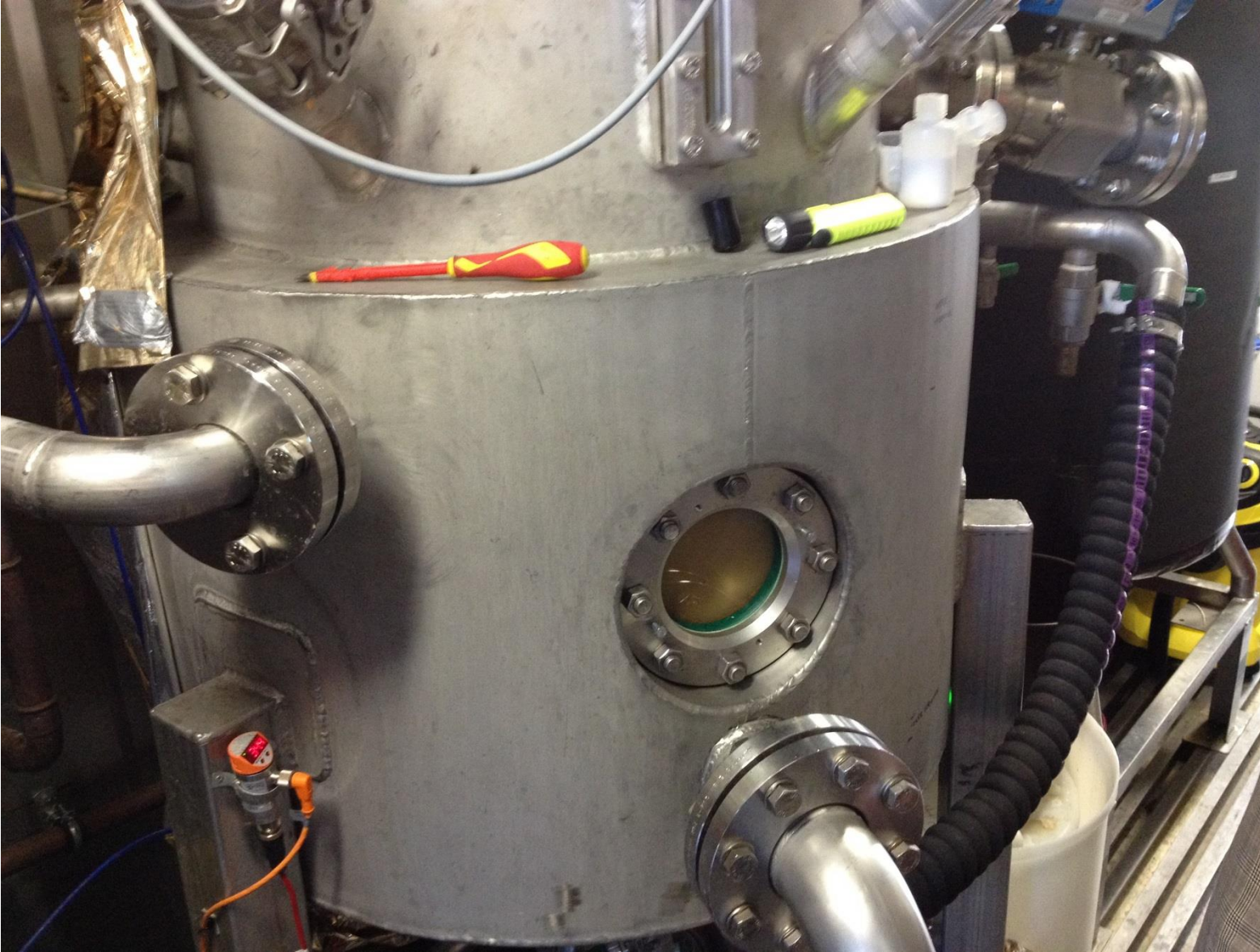
Technical issues

- Some of the pumps got stuck with stones originating from the manure fraction of the biomass.
- This should be avoided in future process design.





Hydrolysate





Operating conditions





Sludge after fermentation was collected more or less every day

