

### Abstract

Continuous processes are known to have numerous potential advantages compared to batch modes. Still, the technology never succeeded on a broader scale for main beer fermentation, mainly due to quality deviations.

Based on the knowledge of previous works, an alternative plant and process concept were therefore developed, in order to efficiently produce a stable, high quality beer in a continuous operated production plant.

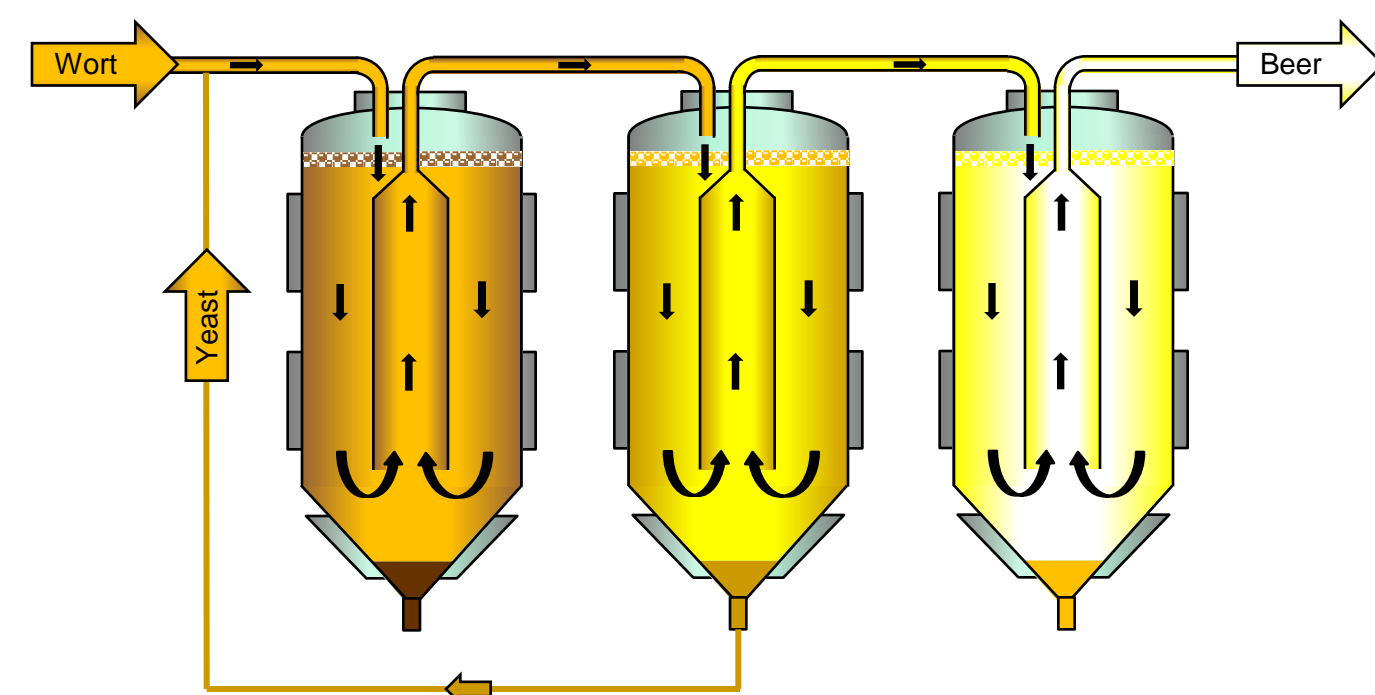
The concept thereby foresees the usage of classical cylindro-conical tanks, which are modified by the installation of central pipes, so that two separate, yet interconnected reaction spaces result. Particles and organisms can sediment conventionally and may be removed and recycled if required.

The findings of numerous preliminary experiments were used in order to construct a pilot scale plant with a daily production capacity of 50 liters. With it, four long-term trials were performed before the ideal parameters were determined to produce beer at the targeted quality.

Currently, a first industrial plant with 40.000 hl/a capacity was commissioned based on the introduced principal.

In a cooperated research project the applicability of the developed processes is being investigated.

### Basic Concept



### Preliminary Trials

Numerous experiments were conducted in order to:

- Identify the ideal storage conditions of wort
- Build small scale fermentors and find appropriate parameters to enable scale ups
- Describe the effect of technological variations during fermentations mathematically, including:
  - inoculation amounts,
  - fermentation temperatures,
  - pressures,
  - aeration rates
- Analyse the yeast vitality more accurate & simple
- Characterize and compare different yeast strains
- Investigate the adaptation rates of brewery yeast strains to stress situations (increased alcohol & high gravity)
- Investigate the effect and necessity of anti-foam-detergents
- Develop an alternative method in order to control the flow profile in continuously operated plants

### Pilot Scale Plant

Based on the findings of the preliminary experiments, a pilot scale plant with a capacity of 50 l/d was constructed and commissioned. In it four long term trials were conducted in order to identify the ideal plant design and processing parameters and compare the results with the previous results



Experiment 1: 29 days  
TUM 34/70

Experiment 2: 28 days  
TUM 34/70

Experiment 3: 37 days  
TUM 34/70

Experiment 4: 57 days  
TUM 193

### Awards & Collaborations

The successful concept was nominated for the "Diesel Medal" in the category: "Most sustainable Innovation" 2013

A collaboration between the Research Centre Weihenstephan (TUM) and the Krones AG was agreed.

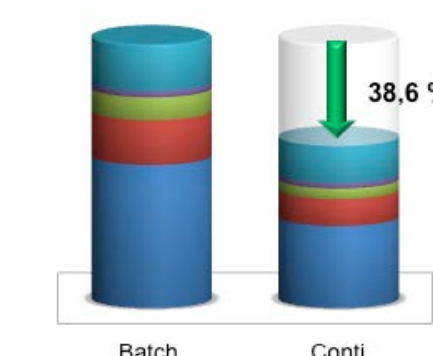


The principal was introduced at the Brau Beviiale in Nürnberg, Germany, 2014 in order to find a brewery as partner, in which industrial sized trials could be performed.

The chosen brewery wanted to expand their capacity from 400.000 hl/a to 800.000 hl/a in the near future.

Based on their production schedule it was calculated, that investment savings from up to 38 % could be achieved (not taking the smaller building and cooling plant into consideration).

Furthermore operational savings of:



- 65 % less extract losses due to adhesions
- 60 % less extract losses due to transfers
- 95 % less losses of CO<sub>2</sub> due to recovery
- 50 % less energy costs for cooling
- 50 % less efforts for CIPing

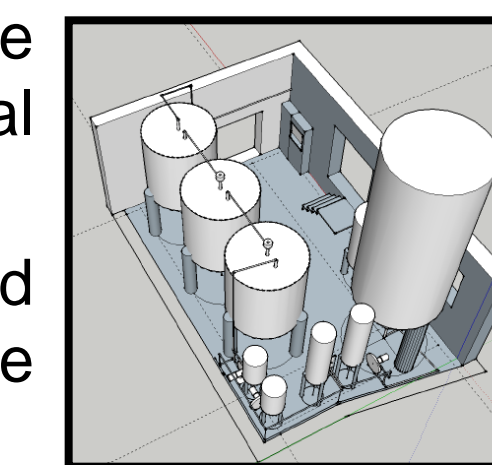
could possibly be expected.

Hence it was decided to test the process in modified yeast tanks, which are necessary in any operation mode.



The chosen tanks can thereby be retrofitted, to common cylindro conical vessels.

Detailed constructions were made and the layout was custom tailored to the specific characteristics of the brewery.



### Goal of the Project

The plant was designed for a daily capacity of 50 hl (wort: 15°Plato) The goal is to produce continuously a stable, pleasant product quality with operation times of at least 3 months.

### Results



- The plant is running stable since its commissioning in the end of June 2016.
- The yeast viability and vitality is on a constant high level.
- The Diacetyl amounts are as low as aimed.
- The product quality is constantly good.
- No microbiological or technological problems occurred.

### Outlook and Discussion

- The plant has to be operated for at least 8 more weeks in order to evaluate its long term performance.
- Subsequently the capacity limits and the effects of higher biomass amounts will be tested.
- Minor plant modifications will be made, before the next scale up step (to 400.000 hl/a) will be discussed and designed.
- Ideally half of the annual production will in the future be fermented continuously.

### Acknowledgement

- Brewery (anonymous)
- Forschungszentrum Weihenstephan
- TUM

- Prof. Dr. F. Jacob
- Dr. M. Hutzler
- Prof. Dr. L. Narziß

### Author Information

Konrad Müller-Auffermann  
Breweries Product Development  
Krones AG, Werk Steinecker

E-mail:  
Konrad.mueller-auffermann@krones.com  
Phone: +49 151 114 018 94