Application of a heat and condensate recovery system in the hop kilning process

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Introduction

After harvest, green hops show water contents of 70 to 80 % which must be reduced to approximately 10 %. During the hop kilning process fresh air is heated to approximately 65 °C. The exhaust air has temperatures of 28 to 35 °C and a relative humidity of up to 100 %. In conventional hop kilning systems the air is released directly into the atmosphere.
With the help of the company WOLF Anlagen-Technik GmbH & Co. KG a pilot heat exchange system was integrated into an industrial size hop kiln in the Hallertau region in Germany (Fig. 1). By heating fresh air with exhaust air the total energy consumption of the kilning process could be decreased. During the harvesting period of 2010, data from industrial scale trials were analysed to evaluate the level of efficiency for the heat exchange system. The condensate of exhaust air with very high moisture content was collected and analysed using GC-MS.

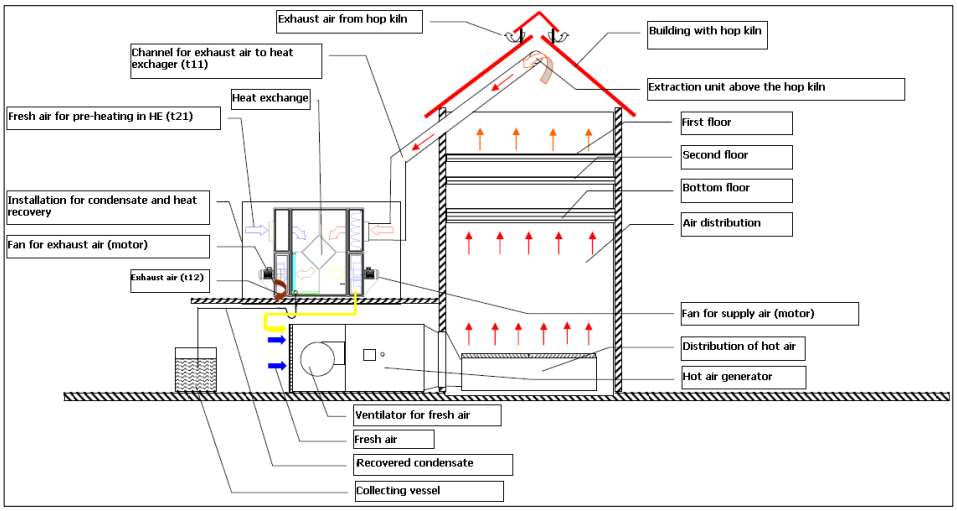

Fig. 1: Hop kiln with heat exchanger for heat and condensate recovery

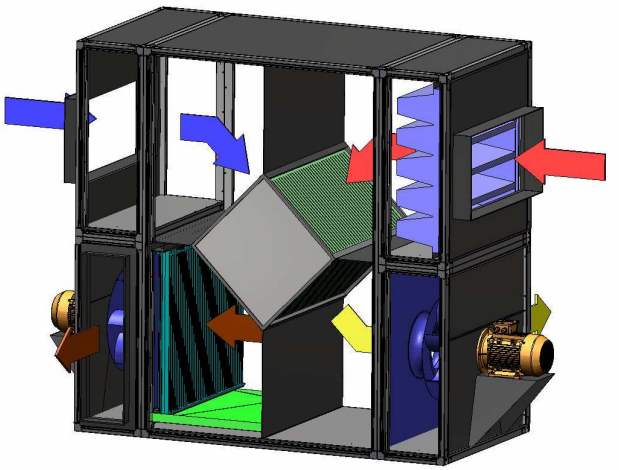

Fig. 2: 3D-drawing of the heat exchanger for energy and condensate recovery

Materials and Methods

The heat exchanger was planned as a module (Fig. 2 & Fig. 3). Integrated are two fans, the heat exchanging unit, a droplet separator and a condensate tray. The pilot heat exchanger was dimensioned for an air volume flow of 10,000 m³/h.
During the harvest of 2010, the efficiency of the heat recovery was monitored. The kilning of six different hop varieties was included. Samples of green and dried hop cones as well as the respective condensate were analysed for each variety. The analyses included HPLC and GC-MS to determine the content of alpha and beta acids as well as eight essential hop oils.

Fig. 3: Heat exchanger with condensate recovery

Results and Discussion

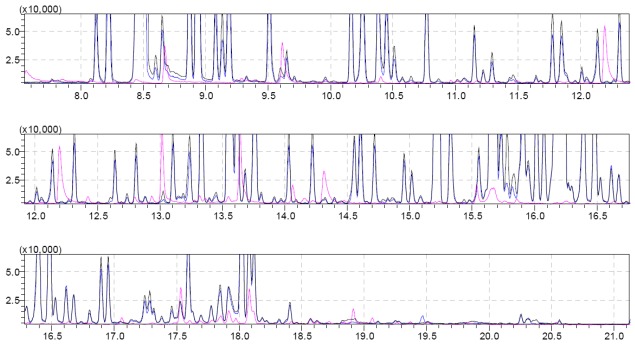

Fig. 4: Chromatogram for Hallertauer Magnum
(black = green hop cones; blue = dried hop cones; pink = condensate)

One of the analysed varieties was Hallertauer Magnum. During kilning, an amount of 0.03 mg/ml hop oils could be recovered from the condensate. The recovered hop oil contained Linalool, Geraniol, Caryophyllene and Humulene in concentrations of up to 0.01 mg/ml. Fig. 4 shows the overlapping chromatograms for green and dried hop cones as well as for the condensate of Hallertauer Magnum. The results of other tested hop varieties were similar.
During the monitored harvesting period, the collected amount of condensate per day was significantly dependant on the weather conditions. In the mean an amount of 9 kg/h condensate was collected. The exhaust air had a mean temperature of 31.25 °C and 62.8 % relative humidity. Post heat exchange the air left the HE-unit with a mean temperature of 23.16 °C and 91.7 % rela tive humidity. In the mean, fresh air was heated from 15.0 °C to 24.4 °C. In parallel the relative humidity decreased from 68.9 % to 39.0 %. A total heat recovery of approximately 50 % was achieved. These figures led to a calculated energy recovery of 38 kW/h or a reduced energy consumption of 20.8 %. According to the current price level a theoretical savings of 2,500.00 Euro per year resulted.

Summary and Perspective

A heat recovery system was installed in a state-of-the-art hop kiln. The heat recovery process resulted in a theoretical energy saving of 20.8 %. Furthermore, the condensate that was produced during the heat recovery contains essential hop oils which could be recovered. For the crop 2011 further trials are planned. Possibly more oil can be recovered with a second condensation or specific absorber material.

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