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Gasifying biomass

Supplying energy is an enterprise with perspective for farms. However, ecological and economical evaluation of such systems can take place only when everything is considered: all technical and agricultural aspects and possible long-term effects. A cooperative project has been created to scientifically investigate the concept and demonstrate practical aspects via a pilot application.

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Keywords

Renewable resources, thermo-chemical gasification, pilot bio power station

Literature

[1] -: Industrie-Rohstoffe vom Acker. Landtechnik 55 (2000), H. 5, S. 328

In Germany so far around 7% of farmland is growing regenerative crop material for industry and energy use [1]. The most important raw material in this context is oil from rape and linseed followed by potato starch. However other industrial raw materials from the field are gaining increasingly in importance. Sunflower oil, for instance, or sugar, medicinal plants, plant fibre and others. Alongside the growing of industrial raw materials, using them for energy self-sufficiency on the farm could be playing an ever-greater role in future agriculture.

Decentral energy production plants on the basis of power and heat output could offer a practical economical and ecological alternative to the conventional dependence on foreign primary energy carriers in the form of electricity and warmth through utilisation of regenerative biomass, harvested by-products and crop waste from agriculture and forestry for farms and communities. The technical utilisation of these bioenergy carriers for energy substitution of fossil fuels or atomic power depends, however, on its acceptance in use by the supply chain and returns on investments and running costs for the necessary plant and equipment. A further aspect is the effect on the environment from the growing of regenerative energy carriers. A technical, ecological and economical evaluation is thus only practical with real objects. Plant costs for building and maintenance are decisively affected by the choice of technology and the achievable total exergetic efficiency of the system. With regard to innovative energy technology (suitable conversion systems, heat transport processes, heat value usage efficiency) there are good saving potentials here which make regenerative crop use in energy production via decentral plants in the context of large agricultural structures appear competitive compared with the importing of energy.

As an agricultural faculty in middle Germany, where farming infrastructure is the strongest in the country, we accept a special responsibility in facing the challenge this production represents.

Appropriate scientific investigations are being conducted within a cooperative project in Saxony-Anhalt. One of the core concepts is the production of three energy forms on-farm:

1. electricity,
2. heat, and
3. cold.

Targets in this context are high exergy efficiency as well as high and continuous utilisation of the plant. Seen as a whole, all three energy forms would be required consistently year-round instead of just one or two of them. In this respect this concept is superior to the well-known power-heat production plants. The core of the investigations is formed by a plant constructed to utilise the bioenergy carriers through thermochemical gasification with parallel production of power, heat and cold.

The most important plant components

Between August and December 2001 on the site of the agricultural faculty a plant complex built by the Thuringia firm T&M ENGINEERING comprises the following main aggregates (*fig. 1*):

Fuel container and conveying equipment

The fuel container with automatic mass determination for control of actual fuel consumption is designed to be easily filled using normal farm equipment (e.g. front loader with shovel). A mixer within the container ensures consistent heaping and transport suitability of the fuel material.

The multi-stage transport of the crop material via auger takes it into the gasification reactor. The multi-stage aspect of the transport and emergency sprinkling facility guarantee high safety standards. During transport, the potential fuel is dried via warm airflow.

Gasification reactor

The contraflow gasifier with ascending gasification was developed in close cooperation by the firm BHF Verfahrenstechnik Kulwitz (near Leipzig) and the Chair of Energy Technology in the Engineering Sciences Special Department at the Martin-Luther University Halle-Wittenberg with a total thermal capacity of 200 kW and maximum fuel consumption of 100 kg per hour. In reduced output consumption can be dropped to ~ 40 kg/h which represents a gas rate of ~ 100 m^3/h.

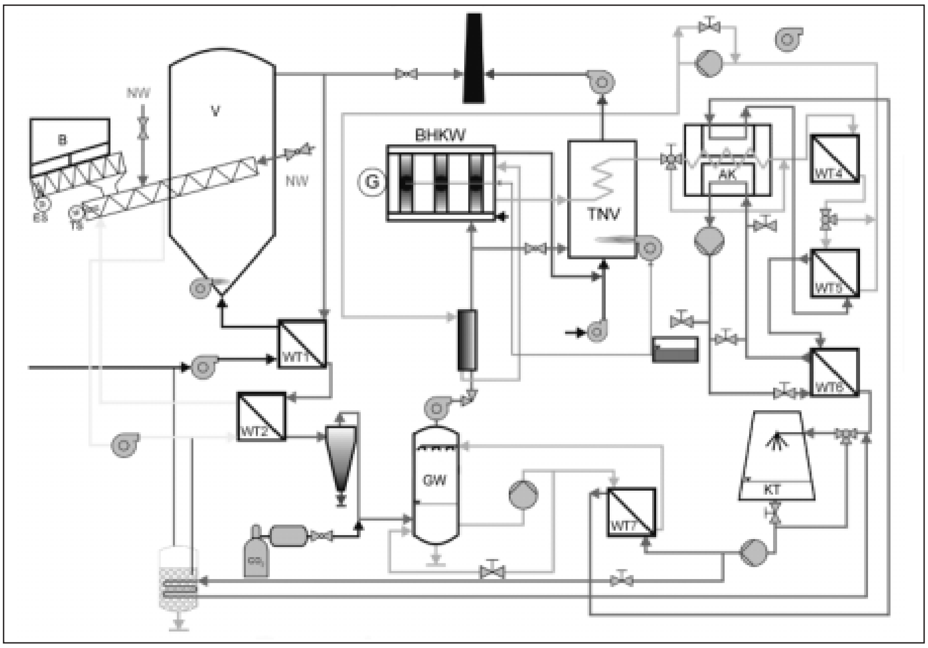

Fig. 1: Scheme of the bio power station (B: container, ES: first worm conveyer, TS: second worm conveyer with dryer; NW: emergency water, V: gasification unit; BHKW: block-type thermal power unit; KT: cooling tower, AK: absorption cooler, GW: gas washer, TNV: thermal post burner, WT: heat exchanger)

Gas filter line

The 700 °C raw gas leaves the gasification reactor and is first cleaned of dust particles in a cyclone before it passes into a wet washer where still remaining cyclic and polycyclic hydrocarbon compounds such as Teeren are removed. The gas is then cooled to ~ 60 °C.

Thermal afterburning (TNV)

Should the produced gas not achieve the required quality for engine use, for instance because of production during starting and shutting down of the gasifier, its use as a burning fuel is planned. Here, a commercial boiler with oil burner and 50 kW thermal capacity is featured. The hot water produced in the 0.5 m^3 boiler would be then available for heating or warm water supply.

Central heating/power plant (BHKW)

The BHKW is based on a diesel engine with attached generator feeding the 30 kW productions into the low tensile network of the agricultural faculty's trial area.

Normally around 10% diesel is added to the gas fuel.

If the biomass gas supply is not sufficient the engine can be driven with 100% diesel or with biodiesel.

Absorption cooling plant

The cooling plant can be powered by using power plant by-product heat (engine and exhaust heat). With a necessary prerunning temperature of 85 to 90 °C cold production capacity of 30 kW$_{el}$ can be achieved. The actual cooling circuit has a prerunning temperature of 12 °C and leaves the cooling plant at ~ 6 °C offering a large number of applications for on-farm use, e.g. milk cooling or storage or food conserving.

Gas analytic

In order to guarantee optimum process management component gases methane, carbon monoxide, carbon dioxide and hydrogen are continuously checked for and recorded via online analysis. Emission protection grounds means that another checking system is run parallel to this for continuous recording of possible proportions of carbon monoxide, carbon dioxide, oxygen, sulphur dioxide and nitrous oxide (NO_x) in exhaust gas.

Process management system

The terminal screen workplace where a total of 56 measurement and control points are simultaneously shown and the working procedure from fuelling to cold production is recorded, complements the whole plant. All the processes of starting-up and running-down the plant and all processes in between are displayed, controlled and recorded over the process management system at this workplace.

The process management system can change the management of the total bioenergy utilisation plant in reaction to the quality of gas being produced so that the operation of the subsequent production procedures in the plant is not affected. If gas quality suffers because of the biofuel being used or the performance of the plant and the fuel is no longer suitable for the engine/generator, then it is possible to change over to biodiesel fuel thus avoiding breakdowns in power or cold production.

The aims of the bioenergy utilisation system

The investigation is comprehensive and covers all energy and environmentally relevant material flows of the regenerative energy plants used here. The project thus looks at the growing of the crops, their harvest transport, processing and storage through to the effective application of electricity, heat and cold on-farm. Results being targeted are:

1. a modelling of the energy and material flows
2. an evaluation of the energetic and exergetic efficacy, and
3. an economical and ecological evaluation of the total system.

Fig. 2: Gasification system (left: gas washer GW, right: thermal post burner TNV)