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Decentralized Biodiesel Production in Agriculture

On 3rd May 2004, a plant for the transesterification of vegetable oils into bio-diesel was inaugurated on the premises of the agricultural operation Barnstädt e.G. in Nemsdorf near Querfurt (Saxony-Anhalt). This plant has a maximum capacity of 900 tonnes per year. This is a novelty in the bio-diesel industry, where average annual plant capacity is 50,000 tonnes. Since the plant's commissioning on 24th May 2004, it has meanwhile shown for six months that it is an economically interesting variant for farmers to produce their own fuel in the form of biodiesel.

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For several years, the agricultural operation Barnstädt e.G. as a partner of 3B-Diesel GmbH has seen the necessity of taking fuel supply into its own hands and thus gaining cost security in the fuel area. After initial trials with pure vegetable oil, which, however, had led to different problems, a solution was sought which enabled the company to produce biodiesel itself.

Fig. 1: View of the entire facility in Barnstädt

Decentralized Process Solution

In the RMEnergy technique, all necessary steps of transesterification are carried out one after the other in a container in a fully automated, batch-wise operation.

All plant- and control systems are housed in a transcontainer (L•W•H = 9.12•2.44•2.79 m). One container area comprises the control systems and peripheral implements, such as the heater, the cooler, the compressor unit, and water processing. The second, larger area accommodates the stainless steel containers, where the necessary methanol-catalyzer mixture is stored and the actual transesterification takes place, along with the required periphery (*Fig. 2*).

Transesterification is carried out in the central reaction container, an insulated, double-walled stainless steel container having a volume of approximately 1,400 litres. For this purpose, the plant first fills itself with an exactly defined mass of vegetable oil. In normal operation, the vegetable oil is heated up during the filling process by hot biodiesel from the previous batch using heat exchangers. Then, methanol in which the catalyzer required for the reaction is already dissolved is added to the pre-heated vegetable oil. Meanwhile, a rotational speed-controlled agitator mixes the reaction partners causing turbulence and thus provides nearly complete transesterification. Due to the special container form, the glycerine produced during the reaction settles in a compact layer. With the aid of special instruments, the separating layer is measured while the glycerine is being drained. In order to reach a sufficient degree of transesterification, the process of transesterification is repeated with a small quantity of methanol.

Some impurities in biodiesel are not separated with glycerine and must therefore be washed out with water. For this reason, oil of average quality is washed twice with ~ 5% water. After the largest part of the water has been separated using gravity separators, the biodiesel is heated up at the end of the process, and water and small residues of methanol are vaporized in a vacuum. On average, this process takes 8 to 10 hours, during which ~ 1,000 litres of biodiesel are produced.

The technical appliance area also includes the mixing container for the methanol-catalyzer mixture, which is situated next to the main container. Here, the plant operator pours one to two 25 kg bags of catalyzer into a feeding funnel once every one to two days. Subsequently, the plant control system calculates the required methanol mass based on the added catalyzer quantity and the set mixture ratio. The methanol is metered exactly, and the catalyzer is added slowly and dissolved in the methanol. All processes are fully automated and controlled by the automatization system AwiControl. Visualization features a simple design in order to guarantee the greatest clarity of operation possible.

For support, the process operator can check the process via the internet and interfere, if necessary. In addition, input- and output quantities can be read directly by the plant operator.

Economic Aspects

Due to the revision of the agricultural diesel regulations, it has become necessary in particular for larger farms to think about alternatives to fossil diesel. The good rape yields of the past campaign led to rape producer prices of € 210 per tonne and less. Based on this price and a calculated rape-cake price of € 120 per tonne, one tonne of rapeseed oil can be produced for less than € 500 per tonne from three tonnes of rape. This corresponds to approximately € 0.45 per litre. At a reasonable plant utilization rate, the production costs of biodiesel by means of decentralized transesterification are below € 0.12 per litre. This has also been confirmed by practical experience. The costs of financing and depreciation account for about 25% and the variable costs for approximately 75% of this amount. The variable costs can be divided as follows:

- The expenses for additives (methanol and catalyzer) amount to about € 0.05 per litre.
- If no heat (~ 95°C) is available, 70 kWh_{el} per tonne or € 0.006 per litre are required.
- The process of biodiesel production is personnel-free because the plant is fully automated. However, the management of raw materials and additives requires personnel. Depending on whether this work can be done „on the side" or employee worktime must be scheduled for this purpose, these costs may vary substantially between € 0.007 and € 0.014 per litre.
- When the biodiesel plant is operated at full capacity, the plant components are not run during 60% of the time because gravity separation takes place during this period. Therefore, maintenance costs are low, ranging between € 0.006 and € 0.008 per litre.

The total variable costs thus reach between € 0.069 and € 0.078 per litre.

Glycerine can be marketed as crude glycerine for processing in large plants in the chemical industry. Utilization in biogas plants, however, is more appropriate. The energy generation potential of the by-products of biogas plants corresponds to a bonus of € 0.03 per litre of biodiesel produced.

Experiences Regarding Product Quality

Past experiences have shown that both the demands of EN 14214, which has been applicable Europe-wide since 2004, and the DIN 51606 standard, which is required by many vehicle manufacturers, are met. With cold-pressed rapeseed oil close to the „Weihenstephan standard" (RK quality standard), this is guaranteed. During the transesterification process, quality fluctuations regarding total soiling, the neutralization number, as well as the phosphorus- and water content, which may occasionally occur in rapeseed oil from decentralized production, can be compensated for without significant expenditures.

Since a reproducible process is guaranteed, the biodiesel always conforms with the standards if raw materials of sufficient quality are used.

If other vegetable oils, such as soya oil, are employed, individual parameters of the standard such as the iodine number or oxidation stability cannot be met reliably. If one single raw material is intended to be used, only rapeseed oil allows the standard to be observed.

Advantages of the Total Concept

In order to avoid dependence and to provide a reliable basis for calculations, it is appropriate to keep the largest part of the production chain within agriculture. In the biodiesel production chain, this goal can be reached through recycling.

Decentralized vegetable oil expellers allow vegetable oil to be produced at low expense if their capacities are utilized appropriately. In addition to vegetable oil, which can be transesterified in a biodiesel plant, rape-cake is obtained, which can either be used as feedstuff to replace imported soya bean meal or used thermically by means of a biogas plant or through direct combustion. During the transesterification of vegetable oil, glycerine is separated from the vegetable oil. According to recent studies, this glycerine can also be used as a feed additive or energetically.

If the rape constituents rape-cake and glycerine are used energetically at the location of the biodiesel plant, the thermal and electric energy gained can be employed for biodiesel production. In the best case, no mineral energy carriers are needed if biodiesel is produced in decentralized plants.

Renewable Raw Material Bonus and Rape

For several reasons, rape or its constituents have not been used for biogas production so far. First, the value added that can be derived from rapeseed-based biogas production does not seem competitive. The second reason, which is more compelling, is the fact that the long-chain fatty acids contained in rape cause severe technological problems. The enrichment of long-chain fatty acids leads to an inhibition of biology and, hence, the biogas process. If these fatty acids are separated, one obtains approximately 50% of the total energy content of the rapeseed, which is available in the form of rape-cake and glycerine. According to several studies, these rape constituents are very suitable for biogas production. Only after the fatty acids have been separated do rape-cake and glycerine become available for effective utilization in a biogas plant.

According to the Renewable Energy Act, one receives the so-called renewable energy bonus, which reaches up to € cent 6.0 per kWh, „if electricity is gained exclusively from plants or plant constituents obtained by agricultural, forestry-, or horticultural operations or during landscape maintenance, which did not undergo any other processing or alteration measures than those required for the harvest as well as conservation or utilization in the biogas plant"[1]).

Thus, the above-described processing meets the requirements of the Renewable Energy Act for the obtention of the renewable energy bonus if these processing steps take place within the agricultural or forestry operation. If the remaining 50% of the energy content of rape (the fatty acids) is used, energy could thus be gained from rape in an extemely efficient manner.

[1]) Law Amending the Legal Regulations Governing Renewable Energies in the Electricity Area, § 8,2.

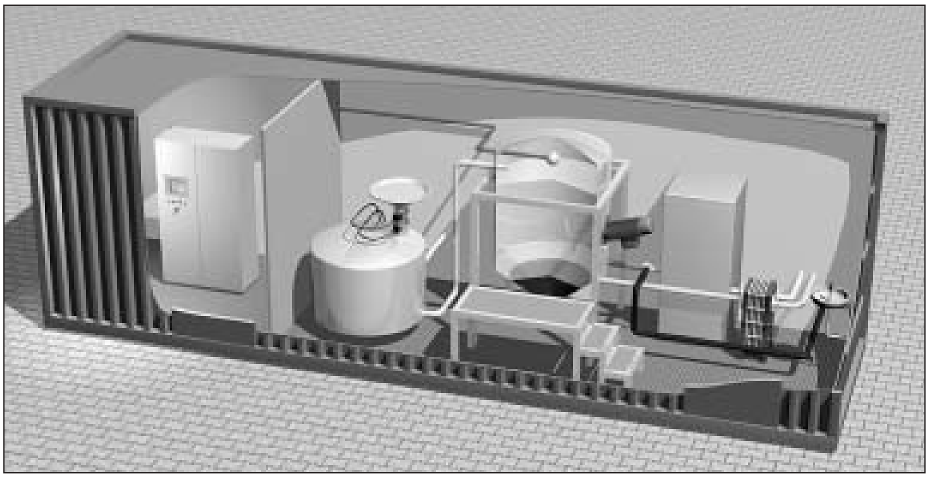

Fig. 2: All components required for decentralized biodiesel production are housed in a transcontainer.