Application Report

Germany's biodiesel capacity growing by leaps and bounds

Biodiesel, the fuel of the future

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Figure 1: Biodiesel installation in Halle-Trotha

Rudolph Diesel developed the peanut oil-fuelled diesel engine in 1894. At the time, he stated in a lecture that ›such oils may perhaps become just as important as mineral oil and bituminous coal currently are over the course of time‹. Today, it can be seen that Rudolph Diesel, even at this early time, showed foresight. Researchers are currently pressing on with this development as the result of increasing environmental awareness, in particular in relation to the greenhouse effect.

According to the ›Union zur Förderung von Öl- und Proteinpflanzen‹ Ufop (Union For Promotion of Oil and Protein Crops), sales of biodiesel have increased virtually 50-fold in the last ten years. In addition, increasing fuel costs have also impacted very greatly on the growth of the biodiesel market in Germany and Europe, see Figure 2.

Even today, up to 5% of biodiesel is admixed to mineral-oil diesel, whereby EU Standards foresee an admixture of up to 10%. In order to cover increasing demand, it is anticipated that production capacity in Germany will be boosted up to 2.3 million metric tons by late 2006. One of the factors contributing to this is the J.C.Neckermann Biodiesel GmbH installation in Halle-Trotha, Germany.

Biodiesel installation in Halle-Trotha

Approx. 56,000 metric tons of biodiesel have been produced per annum using the Lurgi process since September 2005 at the biodiesel installation in Halle-Trotha (see Figure 1). As an additional product, 10,000 metric tons of glycerine (high-quality pharmaceutical grade (99.5 % glycerine) is also refined at the installation. The refinery was constructed over a period of 7 months with an approximate total investment of 19.5 million euros by the Lurgi AG company, Frankfurt, Germany.

The special aspects of the installation include its degumming and neutralisation facilities to purify the rape-seed oil delivered and, consequently, ensuring constant quality of the main raw material.

Process for production of biodiesel

The biodiesel production process is basically an esterification process to produce rape-methyl ester (biodiesel) and glycerine as an additional product through the addition of methanol and a catalyst to the rape-seed oil, see Figure 3. The entire production process from rape-seed oil through to biodiesel can be split into 4 steps: delivery of the starting product and auxiliaries, washing and neutralisation, esterification, and then both rewashing and purification. Raw glycerine that is purified and distilled to produce pharmaceutical glycerine is obtained as an additional product.

The starting products and auxiliaries are delivered and the end products are transported away by tank wagon or road tanker (Figure 4). Even at this stage, it is necessary to comply with explosion protection requirements as methanol and other explosive materials are used in large quantities.

The second process step, purification and neutralisation (oil pretreatment), involves degumming the vegetable oils and greases, and chemically deacidifying them. In a first step, the crude oil is deacidified through the addition of phosphoric acid and the splitting off of phosphatides. The resultant mucilaginous substances, the so-called ›soapstock‹, are separated from the oil in an initial centrifuge (see Figure 5).

In the second stage, washing, the remaining soap is leached out of the neutralised oil and then dried in a vacuum drier.

Before the unprocessed oil enters the washing centrifuge, it is neutralised through the addition of caustic lye soda (sodium hydroxide). This step fully neutralises the previously added phosphoric acid and the residual fatty acids. After the intensive mixing of oil and lye in the centrifugal mixer, the mixture is routed into a separator where the mucilaginous substances are separated off.

The main process, the esterification process, is based on the chemical reaction of triglycerides with methanol to produce methyl ester and glycerine in the presence of an alkaline catalyst. Esterification occurs in two reactors, one connected downstream of the other and each designed as multi-stage reactors, i.e. with different reaction chambers in order to achieve the maximum possible conversion to (rape) methyl ester. Both methanol and catalyst (sodium methylate) are added in parallel to the reactors so as to make the process of esterification possible. The ester compounds of the triglycerides are separated from the rape-seed oil at nominal pressure and temperatures of approx. 60 °C in the first reactor and approx. 50 °C in ➔

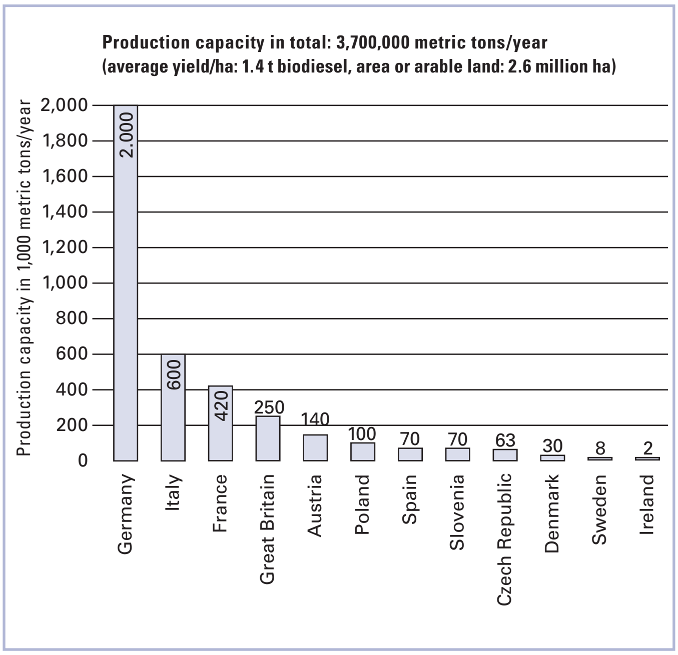

Figure 2: Biodiesel production capacities

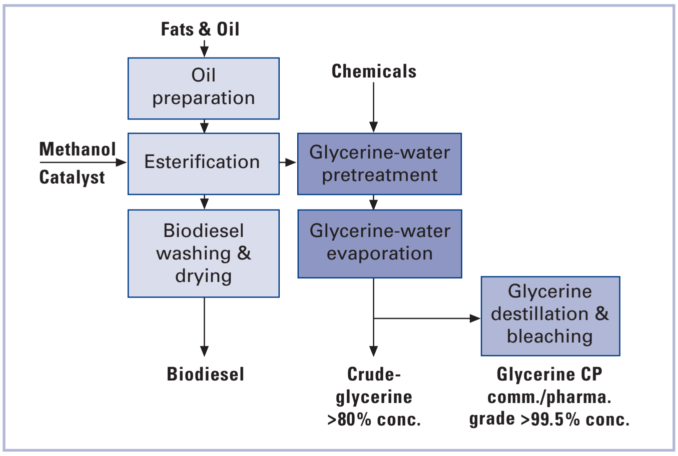

Figure 3: Schematic representation of the esterification process

Figure 4: Loading and unloading facility for the starting products and auxiliaries, and for the end products

Figure 5: Centrifuges for separation and purification

the second reactor. The rape methyl ester (RME) (ρ = 0.88 kg/m^3) and the glycerine (ρ = 1.26 kg/m^3) are separated owing to their differing specific gravities in the so-called phase separators.

The phase rich in ester still contains methanol, glycerine, catalysts, soaps and other components. The water-soluble substances are removed by a washing process before the rape methyl ester is then dried in vacuum driers and finally supplied to the methyl ester store (see Figure 6).

Since the end product, rape methyl ester (RME), has a far lower viscosity than the untreated rape-seed oil, it can be used as an alternative for the mineral diesel fuel without having to adapt the engine. However, it must be ensured that the plastic parts coming into contact with fuel are resistant to the biodiesel.

The phase rich in glycerine is used to obtain a further, valuable by-product, glycerine. This is an important raw material for production of numerous olechemical products. It is used to produce plastics (expanded polyurethanes) and dyestuffs, in creams and ointments (as humectant or moistening agent), and as a foodstuff additive with the designation E 422 (e.g. in jelly babies). In addition, it is used as antifreeze and for synthesis of familiar nitro-glycerine that is used to produce dynamite.

The glyceric water produced as a result of the esterification process is separated from fatty elements in a chemical-physical process. The glyceric water is then heated in a 3-stage evaporation process and the water share is released so that the raw glycerine with approximately 80%-by-volume is produced.

If this concentrated solution is processed in a further distillation step, this achieves a glycerine concentration of 99.5%. This is referred to as pharmaceutical-quality glycerine. This glycerine is used primarily by the cosmetic and pharmaceutical industries.

The entire process of the installation is controlled and monitored from a central control room. The signals of the various field measuring instruments are collected and forwarded via Remote I/O Systems (see Figure 7). Use of the Remote I/O technology significantly reduces wiring and installation costs. The entire measuring and control system was designed and installed by the ALPHA mess-steuer-regeltechnik GmbH company (Leipzig, Germany). Aside from the measurement and control apparatus, the entire installation includes explosion protected, power distribution systems (see Figure 9) and socket outlets in order to also be able to use the safety-related equipment for maintenance and process support.

Of course, the focus was on the technical safety aspects of the installation, along with environment-friendly production. This involved ensuring that the electrical apparatus corresponding to the hazard zones as determined and defined in the risk assessment were used.

Consequently, explosion protected horns that indicate danger in emergencies are used throughout the entire installation. Corresponding emergency luminaries with pictograms guide staff safely out of the installation (Figure 8). The entire installation and wiring work for the electrical apparatus and for the safety-related equipment was performed by the Controlmatic Gesellschaft für Automation und Elektrotechnik mbH company (Schkopau, Germany). The installation is very well-prepared for future requirements thanks to compliance with the environmental and safety-related targets.

Figure 6: Methyl ester store and store for the required additional products

Outlook

Biodiesel fuel top of the league when considering all alternative fuels. Together with other concepts, such as hydrogen propulsion systems and fuel-cell technology, biodiesel will be a mainstay in mobility in the future. The advantages of biodiesel primarily relate to carbon dioxide-neutral combustion and reduced soot emission of about 50% when compared with mineral-oil diesel. One other positive effect of using biodiesel is that virtually self-sufficient production is possible based on domestic resources. Approximately 3,600 kg of rape-seed can be harvested from a one hectare (10,000 sq. m) large rape field, and this produces up to 1,600 l rape-seed oil or biodiesel. The environment-related aspects and the increases in biodiesel capacities in Germany and Europe forecasted offer an ideal position for the installation in Halle. Moreover, it is designed in such a manner so as to allow the capacity to be doubled at any time and, consequently, to allow it to meet future demands at any time.

Figure 7: Station with Remote I/O Systems, with Power Module 9440, Digital Input Module 9470 and Analogue Output Module 9466

Figure 8: Distribution fuse board 8146 with plug and sockets 8570 and 8571, in addition to control devices 8040

Figure 9: Use of the emergency luminaire 6108 with pictogram, and the horn 8491 and fire detector 8146