Mixing of high-capacity tanks for biofuel production

Introduction

There are many possibilities how to mix a batch in an anaerobic reactor. From the energetic viewpoint, there is mostly used mixing by mechanical impellers in stations for biofuel preparation. Impellers use to be mostly placed centrally on a shaft or they are built in sidewalls of a tank according to a tank capacity or more likely according to their arrangement (especially ratio of liquid level and tank diameter). Type of impellers, their adjustment, and relative size have to be chosen properly and also impeller speed and power consumption have to be determined correctly during fermenter design.

Impellers must fulfill many tasks in a reactor – they must ensure homogenization of a batch and especially they must prevent heavier particles from settling down to a vessel bottom resp. lighter particles from drifting up to a liquid level. At fermentation, it is sufficient when impellers work only for short time periods, because for the process requirements it is necessary to provide casual re-arrangement of substrate in whole reactor so the fermentation process takes place in the whole batch preferably uniformly.

In recent years many new stations for biofuel preparation are built in the Czech Republic. In the fermentation process technology fermenters of high-capacity are used. These large tanks have to be mixed and due to their size, side impellers are used for this purpose. A fermenter is generally constructed as a cylindrical vessel with flat (at large scales) or conic (at low scales) bottom. Mixing in large tanks is not simple especially when both solids heavier and lighter than liquid have to be mixed so they don't settle on a vessel bottom resp. at a liquid level.

In a literature, data about mixing of a batch in large tanks using side impellers can be found particularly in terms of the crude oil storage tank homogenization. For example, Rushton [1] and Oldshue et al [2] dealt with determination of optimal positioning of an impeller. However in addition to the homogenization, in case of anaerobic fermenters for biofuel generation it is also important to take in mind the above mentioned prevention of solids settling and drifting up or even assurance of wetting of light solid phase at a liquid level and its sinking under the level. There isn't enough information about this complex process of mixing using side impellers in a literature. Therefore some experimental were done in this work to supply new pieces of knowledge about this problem.

Experimental

The experiments were carried out in flat-bottomed transparent cylindrical vessel of inside diameter $T = 600$ mm. The vessel was geometrically similar to a real fermentation tank. Side impellers (corresponding to the real state) were supplied in correspondence with measurements of Fox and Gex [3] by jets, because the size of the impellers was too small due to the used scale of the experiment. The whole experimental layout is shown in Fig. 1.

The equipment enabled changing of all of the geometrical positioning parameters of jets (impellers), i.e. their height under a liquid level or above the vessel bottom $h_i$, horizontal positioning $\gamma_{i}$ and also the horizontal ($\beta_{i}$) and vertical ($\alpha_{i}$) inclination (see Fig. 2). The concrete values of all of the parameters at all of the tested configurations are listed in Table 1.

![Fig. 1. Experimental layout of the laboratory scaled equipment](image1)

![Fig. 2. Layout of jets (impellers) and variability of their positions in the vessel](image2)
The localized configuration at the liquid level, which is necessary for wetting and sucking of particles under the liquid level, was determined (Table 1 – configuration D). In case of such configuration, the power consumption at the level must be increased by usage of higher-performance impeller or by increasing of number of impellers, or eventually by increasing of number of impellers installed in the same way of inclination at the same place just above each other as it is shown in Fig. 3. This layout then allows us to use the same type of side impellers in the whole tank.

Conclusions

On the basis of experimental results, three impellers positioned symmetrically along the vessel diameter and along the liquid level height were found out as the optimal configuration for good circulation of batch in high-capacity tanks. Their height positioning and vertical and horizontal inclination was determined (Table 1 – configuration D). In case of light solid phase floating on a liquid level, local power consumption at the level must be increased by usage of higher-performance impeller or by increasing of number of impellers (Fig. 3).

In smaller tanks, just one impeller with sufficient power consumption and placed under the liquid level can be used for mixing in fermenters. The determined angles of inclinations and positioning of the impeller is listed in Table 1 (configuration G).

REFERENCES