PAC

Process Analytical Chemistry - Data Acquisition and Data Processing

Main location	Linz (Upper Austria)
Other locations	Kundl (Tirol), Salzburg, Lenzing (Upper Austria), Krems (Lower Austria), Vienna
Thematic field	The major target of the PAC consortium is to perform real time measurements of chemical information directly from the process streams. This online data should open new optimization potentials for chemical processes in various industries.

Success story summary

Online viscosity sensing

The knowledge of different process parameters allows the optimization of chemical and biological processes.

Besides optical measurement methods, which mainly analyze the chemical composition of the samples, the detection of physical properties such as the viscosity of fluids is important. By using viscosity as a reference value, it is possible to deduce the reaction process or to calculate the mixing ratio of two (differently viscous) liquids.

In addition to traditional laboratory measurement techniques, which determine the average viscosity of larger sample volumes, miniaturized sensors are used. This makes it possible to analyze also small amounts of liquids online. In the research project new sensor principles, appropriate production technologies and their comparability with the classical measurement methods are investigated.

Success story

In order to optimize the quality and gain of chemical and biological processes, it is necessary to know a large variety of process parameters. In addition to optical methods, which mainly analyze the chemical composition of the samples, the detection of physical properties such as viscosity or density of liquids are important. Both of these parameters make it possible to deduce the current reaction conditions and to characterize the liquid for further processing.

In order to determine the parameters directly in the process, so-called "online viscometers" are used. However, most of them suffer from the connection of a motor via precision bearing and sealing to the sensor head which has to be mounted directly in the production line. This leads to a reduced accuracy, increased maintenance costs and also very restricted local flexibility.

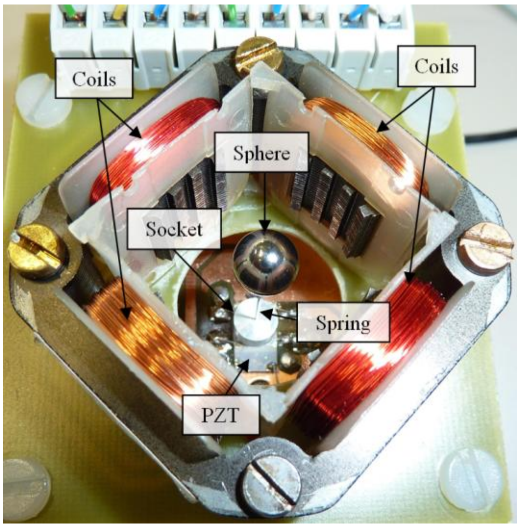

Fig. 1: Electromagnetic measurement system.

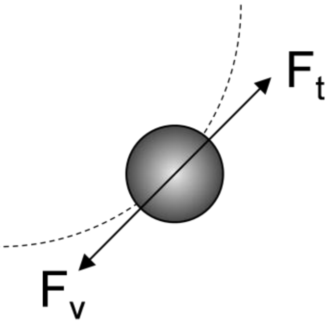

Fig. 2: Viscous drag force (F_v) and electromagnetically generated tangential force (F_t) acting on the ball.

The viscosity measurement system shown in Fig. 1 avoids these problems. It imitates the falling ball viscometer, which is an established and widely used method for laboratory viscosity measurements. Therefore the linear motion of the sphere, driven by gravity, was replaced by a circular motion, actuated electromagnetically, which allows for continuous measurements. For this purpose, a metal sphere is mounted on a spring and placed in the middle of four electromagnets. If these electromagnets are driven accordingly the sphere performs movements on a circular path. This type of actuation permits to control both, the force and the rotation speed of the sphere, so the circular path can be controlled precisely. In the steady state, the tangential force acting on the ball is in equilibrium with the viscous drag force (see figure 2). By varying the speed of the ball, it is possible to perform measurements in different rheological domains (rheology is the study of the flow processes). Moreover, in addition to the viscosity also the density of the fluids can be determined.

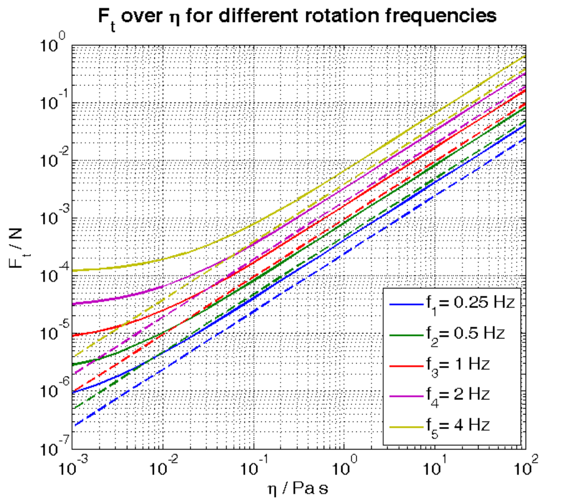

Fig. 3: Representation of the tangential force on the ball about different viscosities and at different rotational speeds.

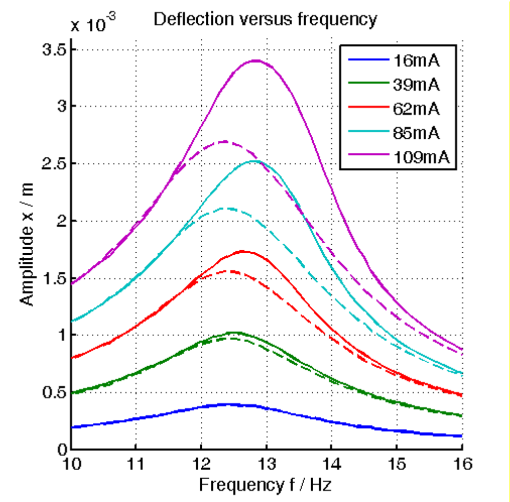

Fig. 4: Representation of sphere deflection in oscillating and circling mode.

Figure 3 shows simulation results for the measurement system. The linear relationship between viscosity and tangential force results in a very simple mathematical model usable in the range of low Reynolds numbers.

Figure 4 shows typical resonance curves of the measurement system with different actuation current amplitudes. The solid lines represent the circling excitation mode and the dashed lines belong to the translational vibrating mode.

The very simple structure of the measuring system can be divided into two spatially separated parts. The ball, as well as their spring wire, can go directly into a (non-metallic) pipe, while the actuation coils that can also be used for position measurement are outside the tube. Implementing this separation, no parts from outside into the pipe system are needed. Furthermore, the system is entirely free of rotating components, therefore bearings and special seals are unnecessary.

Optimized chemical and biological processes are a further step in the direction of a resource and environment friendly technology.

Impact and effects

With miniaturized viscosity sensors it is possible to perform measurements online during the production process, for example to provide information about the progression of the reaction or the quality of the product. Due to lower manufacturing costs, a large number of such sensors, which allow the observation of the process at different positions, could be installed.

Combining this information with the knowledge of the reaction behavior, the process can be controlled to run at optimum conditions; so that, with minimal use of resources an optimal result can be achieved.

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