Onstream Analyzers

The term analyzer refers to any sensor that measures a physical property of the process material. This property could relate to purity (e.g., mole % of various components), a basic physical property (e.g., density or viscosity), or an indication of product quality demanded by the customers in the final use of the material (e.g., gasoline octane or fuel heating value).

Analyzers rely on a wide range of physical principles; their unifying characteristic is a greatly increased sensor complexity when compared with the standard temperature, flow, pressure and level (T, F, P, and L) sensors. In many situations, the analyzer is located in a centralized laboratory and processes samples collected at the plant and transported to the laboratory. This procedure reduces the cost of the analyzer, but it introduces long delays before a measurement is available for use in plant operations.

Analyzers can be located near the process equipment to provide real-time measurements of variables for use in plant operations and control. Clearly, the availability of key process variables (*beyond* T, F ,P , and L) provide the possibility of improved dynamic performance leading to increased safety, consistently high product quality and higher profits. In general, these benefits are gained at the expense of higher sensor cost and lower reliability; thus, the engineer should perform an economic analysis considering benefits and costs before deciding to install an on-stream analyzer.

The alternative approach involves feedback control of **inferential variables** (see Marlin, Chapter 17, 1995), perhaps coupled with infrequent laboratory analysis. Both on-stream analyzers and inferential variables are used widely in the process industries; the proper selection of sensor and control technology depends on the costs and benefits for each specific application.

Onstream analyzers utilize many different physical principles, and a survey of these analyzers requires a large body of material, typically at least one full-sized book (e.g., Clevett, 1985). In this section, some of the key factors applicable to many analyzers are reviewed; these factors are independent of the specific physics and chemistry of the analyzer principle. The main general issue is the need for a sample system for many on-stream analyzers.

The purpose of a **sample system** is to extract a representative sample of the fluid, preprocess the material so that the analyzer can perform its function, and dispose of the effluent after the analysis has been completed. A typical sample system is shown in Figure 6. The sample design contributes to achieving the goal of extracting material that represents the total stream properties. Typically, the sample probe (pipe into which the sample flows) has its opening located near the center of the process pipe. Its openings can be arranged to limit the extraction of entrained solids and gases. The flow rate of the sample from the process to the analyzer should be very high even though the analyzer may require only a small amount of material. This “fast loop” of sample flow prevents a long transportation lag, i.e., dead time, in the analyzer sample system. Naturally, this design requires a large amount of material to be sampled, and it should be returned to the process for economic and environmental reasons.

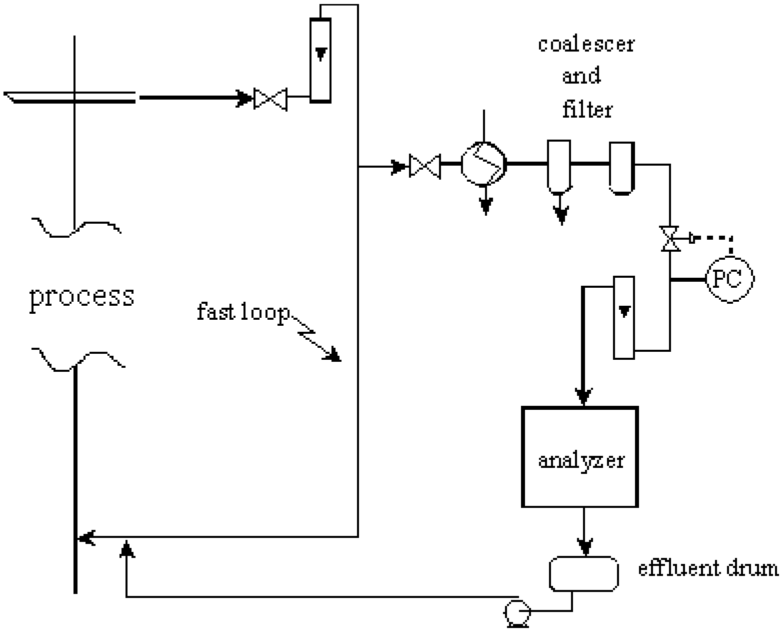

Figure 6. Typical sample system for on-stream analyzer.

A smaller sample for analysis is taken from the fast loop. This sample needs to be **preprocessed or "conditioned"** to ensure that it is acceptable for the analyzer. For example, the sample might be heated to ensure continuous flow of a material that might solidify, or it might be cooled to satisfy limits of the analyzer equipment. In addition, the pressure is regulated to ensure that a large pressure surge in the process is not transmitted to a sensitive analyzer. A pressure regulator is often used; this is a self-contained sensor, proportional controller and valve which provides low cost and reliable protection, but not exact control. Finally, limited physical separation to protect the analyzer may be advantageous; often, a filter is used to remove fine particulate matter, and a coalescer can separate undesired liquid components, for example, occasional water in a hydrocarbon stream.

The **flow** of the stream to the analyzer should be regulated. This flow could be continuous or periodic, depending on the requirements of the analyzer. For example, a chromatogragh requires a periodic flow and provides periodic or discrete values of the measured variable. A continuous stream might be regulated by a rotameter, and a periodic flow could be regulated by electrically operated on/off (solenoid) valves.

All **effluent** material, whether or not it was processed by the analyzer, must be disposed of properly. The best approach is to return all material to the process. This requires either a collection vessel with a pumped return flow or a return to the process at a lower pressure than the analyzer effluent. Environmentally benign material can be vented to the atmosphere or sewer.

Two additional sources of material are common. For startup, shutdown, and pressure testing, a source of clean fluid is required to fill and flush the system. For checking the performance of the on-stream analyzer, a source of fluid with known properties (a **calibration sample**) is provided, and the plant personnel can divert the process sample and send a test sample to the analyzer. This procedure contributes to confidence in the analyzer and much greater use of the measured value in timely decisions.

Finally, the analyzer and sample equipment physically near the analyzer are often located inside an enclosure, an **“analyzer house”**, which can be temperature controlled. This provides shelter for the sensitive electronics and measurement equipment. Also, the shelter provides a barrier between the atmosphere in the plant which might (even very infrequently) contain explosive vapors and the electronic power need by the analyzer.

Clearly, an on-stream analyzer involves a complicated system of flow, pressure and temperature control in addition to the analyzer itself. As a result, the installed cost of an on-stream analyzer can be more than twice the cost of the analyzer alone for laboratory use. An additional cost results from the frequent maintenance of the analyzer; a rough guideline is that one technician working 40 hours per week can maintain about 10-15 on-stream analyzers. However, the measurement and tight control of product quality provide **substantial benefits,** which justify the total cost of many analyzers (for example, Bajek et al, 1987; Black et al, 1987; Marlin et al, 1987)

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