Make Flow Metering Scientific! – III

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We have emphasized that flow metering requires science. Science here refers to modern science since Copernicus, Galileo, and Newton, not Greek science. I will leave it to others to discuss the essential difference between science and technology, but to put it simply, the relationship between them is the relationship that was achieved by incorporating science into technology when technique evolved into technology. In other words, science is the logos of technology.

Then, the current flow metering, which is the subject under discussion here, is a technique with no science in principle, insofar as Q = AV, and as such, the technological development has stopped as it is. Of course, some progress may be allowed. Ultrasonic flowmeters can be seen as covering part of the principle by using the average of the velocity distribution at the measurement site, and Coriolis flowmeters can be said to be based entirely on scientific principles. In this light, it makes sense that they are gaining a larger share of the market.

According to Yoichiro Murakami, it is technology that has clients, so with that in mind, let's take a bird's eye view of the current state of flow metering and flow meters as a technology.

Flow Meters and Flow Sensors

There is no distinction between weighing instruments for the transaction of goods and instruments for monitoring or instrumentation to ascertain the condition of equipment. The former, as mentioned earlier, has been developed since Roman times out of necessity for social operation, and the market has been established without any room for science. The market size in Japan is said to be around 400 billion yen and 4 trillion yen worldwide, so they are not small for measuring instruments, and the economic system and legal regulations that match their technological level have been fully established worldwide. As a result, even if the need for improvement is understood, it will take tremendous effort and time to break out of this paradigm. It would be even more difficult to expand the volume within that paradigm beyond the current level.

On the other hand, it seems that not much has been done to develop technology for instruments for monitoring or instrumentation of plant facilities and equipment. In contrast, not much has been done to develop technology for monitoring instrumentation or monitoring equipment for plant facilities and equipment. The monitoring equipment is, simply put, a flow sensor. As mentioned in the previous section, metering flowmeters have strict conditions of use to ensure their accuracy, and it is not so easy to reliably realize them in monitoring equipment. For example, it is not realistic to secure a sufficient developmental area upstream of the measurement device or to satisfy transient response. Moreover, the environment in which the equipment is installed cannot be as preferential as that of a metrological device. In other words, the spatial and temporal conditions are more demanding.

In the end, it is necessary to properly develop flow meters = flow sensors as monitoring devices. In this case, it is not a mere extension of old devices and methods, but a technological development that incorporates science or is based on science. The following is a case in point.

Industrie 4.0

Within the scope of the past decade or so, there has been much talk of a fourth industrial revolution in Europe, especially in Germany, a country with advanced industrial technology, under the designation Industrie 4.0. This is the name of the national goal[18] for the next industrial development, which was set around 2010 on the basis of the Federation of German Industrial Technology, and for a while I4.0 was spoken of everywhere. The details of the I4.0 are not for the reader to examine, but I would like to introduce the essence or the key story of the I4.0. In setting Germany's industrial targets, the idea was that Germany should specialize in research and development of manufacturing machinery, leaving the production of so-called commodities to other countries. This is a follow-up to the first industrial revolution of mechanization, the second revolution of the mass production system based on the full use of electric energy, and the third revolution of information technology (that is why it is called 4.0), and it is a shift from the previous idea of assembling and controlling the entire system based on a centralized conception to the idea that each component (block) of a plant should be able to operate autonomously. The idea is to make it possible for each component (block) that makes up the plant to operate autonomously and to optimize its local operation, and then to configure the entire plant. Incidentally, Japan has also adopted a policy called "Society 5.0," which seems to have been inspired by this concept, but it is too ideological to be systematized in any concrete way. Similarly, the U.S. and China have also established science and technology policies that seem to follow the Society 5.0, but unlike Industrie 4.0, these are only policy-oriented.

One of the key elements in the transformation of industrial technology in accordance with the Industrie 4.0 philosophy is that each block must be able to operate autonomously. This means that each block must be able to operate as if it were a single unit that is locally optimized within itself. To achieve this, it is necessary, to use a simple example, to have an integrated system that can hear itself, collect, evaluate, and manage information, and operate autonomously and harmoniously with the whole system. This is also called a smart factory. In this context, it should be obvious that sensors will become even more important. Even the development of autonomous robots, which is currently very popular, would be impossible without sensors to grasp the status and condition of the robots themselves. And the subject of this paper is a sensor to know the amount of material (material or product) moving within those systems (inside a block) or between blocks, i.e., a flow sensor.

Smart factory

The Sensor Council document[19] is at hand. The document lists the need for various types of sensors and their development requirements in many situations and circumstances, including energy, smart factories, smart agriculture, and marine development, among others. In particular, in relation to Industrie 4.0, the need for sensor development within the framework of smart factories is specifically mentioned, and as mentioned above, the movement of materials and products in each block of a plant and the autonomous operation of the block from its monitoring are cited as goals. Although not specifically mentioned in this paper, the data is naturally digitalized and the operation is assumed to be IIoT (Industrial IoT). And of course the information transmitted by those sensors is assumed to be scientific in its measurement technology and not empirical. At this stage, it will be clear that current flow sensors cannot qualify.

Summary: Flow sensor

As mentioned at the outset, the recent revolution in flow field measurement technology has made direct supplementation of the flow field sufficiently feasible that flow metering by direct methods can now be realized. Moreover, this also indicates that it is possible to overcome a major obstacle to the future development of the industry. The following is a visualization of the changes that will occur in industry when flow sensors with such new characteristics are realized.

It is a return to measurement in accordance with the basic scientific principle of direct observation of natural phenomena. Because it is a direct measurement of the flow field, rather than an indirect measurement using other natural phenomena, the information is no longer filtered or biased one step in terms of information theory, and the presumptions and assumptions necessary for its application are no longer necessary. In other words, the results can be trusted as is. There is no longer a need for a rectifier to grow and orient the flow in the upstream straight section of the flowmeter, which is a requirement for most flowmeter installations, and no need to worry about the range of applicable Re numbers. If the two-dimensionality can be properly verified, it would be possible to install the system immediately after an extreme bend in the pipe. In principle, it does not matter whether the flow is laminar or turbulent. Depending on the measurement method, the transient nature of the flow state can be followed by the time constant of the measurement method and the surrounding signal processing.

These have the potential to greatly improve current plant and piping systems. The installation requirements for flow-capacity flows would be greatly eased, for example, the larger the pipe diameter, the greater the effect. If a 5-20D straight pipe section upstream is no longer needed, not only will space be saved, but also the pressure drop in the flow path will be reduced and Inventory will be reduced. Naturally, if such installation requirements are eliminated, the flowmeter itself can be downsized sufficiently, and flow metering sensors can be realized.

In addition, the ability to obtain flow rates as a function of time with a sufficiently small temporal resolution means that the above would work well for use in the control system of a plant. This would speed up the response time of the plant, which would lead to a significant improvement in the control system. Manufacturing, especially in chemical engineering and food processing engineering, is all about separating or mixing materials, and accurately grasping the flow rate of the materials is fundamental to process control, so knowing this correctly is also fundamental.

In the basic concepts of IIoT and Industrie 4.0, which are currently being advocated worldwide, especially in Germany, the manufacturing process is blocked and componentized, and each element is optimized independently. Since each component needs to function completely independently within it, it eventually needs a high-quality sensor to understand the situation, equivalent to eyes and ears. In this case, as long as only the flowmeter employs FS accuracy, it will be at a great disadvantage and the flowmeter will be left behind, since it cannot be evaluated and totalized in integration with the other elements. This is because it is necessary to make sure that the physical quantity measured by the flow sensor is not used by itself, but evaluated in conjunction with other parameters.

The need for flow sensors has been identified in many situations. An example in a smart factory.

Summary: Flowmeter

While this paper has mainly discussed flow sensors, more stringent conditions are imposed on flow meters, as discussed in the previous two chapters. This is because the measured physical quantity itself is used in the social and economic environment of commercial transactions. In other words, the relaxation or abandonment of the installation conditions of the instruments and the change in the notation of measurement accuracy represent a departure from the so-called paradigm, or a paradigm shift. Therefore, it is desirable to adopt a method that is based on rationality-based science and that eliminates subjectivity as much as possible.

The principle is to rigorously measure and evaluate the flow field directly where needed, and the methods relied upon over the past 2000 years should be broken away to create a new paradigm. And this is fully possible with today's technology.

Finally

Such a change in measurement principle would require considerable effort and time to establish itself and be accepted, but it would not render the current system, such as verification methods and type approval, useless. Considering the maintenance of the users themselves, it would be possible to simplify the system itself, but it would not necessitate a drastic change.

Our goal is not revolution, but bold innovation in technology, which is the true emergence of innovation.

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