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Sergii Shamanskyi

CREDIBILITY GUARANTEEING OF METERS READOUTS

National Aviation University
1, Kosmonavta Komarova avenue, Kyiv, 03680, Ukraine
E-mail: Shamanskiy_s_i@mail.ru

Abstract. *The article deals with a credibility problem of resource amounts calculation. The calculation is based on periodical readouts of meters registrations. We propose a model of readout errors calculation and an estimation model of time lags between the readouts to provide errors in a necessary range.*

Keywords: calibration; consumable resource; credibility; heat energy meter; measuring device; meters registration; readout error.

1. Introduction

The necessity to measure consumable resources (such as water, thermal energy, gas, electric energy and others) is obvious. Flow meters and amount meters of liquids and gases find more and more application both in the economy of our country and in the world on the whole. Utility of these devices is determined by many factors [1]. One of the principal factors is reliability of measuring results.

Today a lot of measuring devices operate remotely. They can be parts of telemetric systems, passing over information to control stations, where it is processed into the form that is suitable for treatment and storage. However, the part of measuring devices which can not operate remotely and need people to read out information from their dial plates or displays is still substantial.

Credibility of measuring results depends on accuracy (error) of fixing of flow rate or amount of consumable resource. While using devices without telecommunication accuracy (error) can be determined by two major components. The first is an error of measuring device. The second is an error (credibility) of read-out the information. Experience shows us that in many cases providing credibility of readouts is an urgent task. Unreliable measuring information can result in misunderstanding, and sometimes can lead to conflicts.

Readout errors can occur due to several reasons. For example, there are reasons that are related to human factor: carelessness, uncomfortable dial plate, accidental gross error and others. There are also reasons that are not related to human factor. One of such reasons is rounding off error. Each device has limited amount of digits on its dial plate or display. Therefore, during read-out a person has to round off a result, consciously introducing an error. If a period of time between consecutive read-outs is large enough this error is unimportant. For example, read-outs of a water meter or a gas meter, which is mounted in an apartment, are usually implemented monthly. In this case a question of providing high read-out accuracy is not critical. A consumer knows an average amount of the resource consumption during an average month. Therefore a probability of making a gross read-out error is low enough. At a case of making an insignificant error, including round off error, with overstating or understating the amount of the consumed resource, it can be easily corrected at the next read out next month.

Problems spring up if it is necessary to evaluate flow rate or amount of the consumed resource during a short period of time. At this case guaranteeing read outs credibility becomes a very important task.

2. Analysis of the latest research and publications

Let us make suggestions related to guaranteeing of read out credibility.

The necessity of a consumed recourse amount controlling during a short period of time arises in many cases. For example: during production processes, during calibrations of meters etc. Calibration of water meters by utility workers can be conducted in two basic ways: at a special laboratory on a calibrating rig, or directly on a water meter placement location with the help of a portable measuring capacity.

Every water metering post has stop valves directly before the water meter and after it. On a pipeline between the meter and stop valve after him a flow-off fitting (short branch of pipeline) is mounted. The fitting is equipped with a valve, normally closed. The fitting with the valve can perform several tasks. It can be used for emptying the consumer's pipeline, establishing a manometer for controlling pressure in the pipeline, for washing the pipeline after corrective maintenance has been done and others like that. In addition, it can be used for water meter calibration without demounting it from the pipeline. For carrying out the calibration a certain amount of water is let through the water meter and the fitting into a portable measuring capacity. Then the amount of water in the capacity is compared to the amount of water registered by the water meter. Based on this, a measurement error of the water meter is calculated and made a conclusion about possibility of the subsequent usage of the device. Accuracy (error) of the read-out in this case is extraordinarily important.

One of the methods of heat energy meters calibration without demounting it from a pipeline is comparing the amount of consumed thermal energy, calculated on the base of read outs of the sensors of heat carrier amount and sensors of heat carrier temperature, to the same amount of the consumed heat energy shown by the integrator of heat energy amount. In this case the errors of all sensors (heat carrier amount, heat carrier temperature) and the integrator read out's rounding off is also very important.

Let's consider it using the next example. A calibration of two heat energy meters without demounting them from a heat conduit was carried out by representatives of a heating supply company in one of the Ukrainian cities. The meters were of type УСТ – 95/1-50-03. The calibration was conducted using the method described before. Meanwhile 1 hour time interval between read outs was chosen, which was too short.

As a result of comparing manual computation of enthalpy (amount of thermal energy), based on read outs of the sensors of heat carrier amount and sensors of heat carrier temperature, with amount of thermal energy shown by the integrator, a considerable divergence was diagnosed. The registrations of the first meter at the beginning of the experiment were: of the integrator Q_{1b} = 7215.1 *GJ*, of the sensor of heat carrier amount V_{1b} = 98602.8 m^3. Difference between the temperature of heat carrier in delivery pipeline and return pipeline Δ_{1b} = 35 ^{0}C. At the end of the experiment they correspondingly were: of the integrator Q_{1e} = 7215.2 *GJ*, of the sensor of heat carrier amount V_{1e} = 98603.9 m^3, difference of heat carrier temperature Δ_{1e} = 34 ^{0}C. The same registrations of the second meter at the beginning of the experiment were: Q_{2b} = 0622.7 *GJ*, V_{2b} = 92093.3 m^3, Δ_{2b} = 38 ^{o}C. At the end of the experiment they were: Q_{2e} = 0623.0 *GJ*, V_{2e} = 92095.1 m^3, Δ_{2e} = 37 ^{o}C.

In the first case consumed amount of thermal energy according to the integrator was

$$\Delta Q_1 = 7215{,}2 - 7215{,}1 = 0{,}1\ (GJ),$$

and the amount of passed through heat carrier was

$$\Delta V_1 = 98603{,}9 - 98602{,}8 = 1{,}1\ (\text{m}^3).$$

It means that the amount of consumed thermal energy according to sensors of heat carrier amount registrations (provided that the average temperature difference was Δ_{1av} = 34.5 ^{0}C) formed

$$G_1 = \frac{1.1}{1000} \cdot 34{,}5 \cdot 4{,}1868 = 0{,}159\ (GJ).$$

Divergence (relative error) of two energy amounts was

$$\delta_1 = \frac{0{,}159 - 0.1}{0{,}159} \times 100 = 37\ \%.$$

In the second case consumed amount of thermal energy according to the integrator was $\Delta Q_2 = 0{,}3\ (GJ)$, the amount of passed through heat carrier was $V_2 = 1{,}8\ (m^3)$. Thus, consumed amount of thermal energy, according to sensors of heat carrier amount registrations (provided that the average temperature difference was Δ_{2cep} = 37,5 ^{o}C) formed

$$G_1 = \frac{1.8}{1000} \cdot 37{,}5 \cdot 4{,}1868 = 0{,}283\ (GJ).$$

Divergence (relative error) of two energy amounts was

$$\delta_2 = \frac{0{,}3 - 0{,}283}{0{,}283} \times 100 = 6\ \%.$$

Based on the results of this experiment, We made a conclusion about uselessness of both thermal energy meters for commercial accounting because of the errors that exceeded the limit, which is 3 %.

Let's reveal that the calibration was conducted incorrectly by the reason of not providing credibility of read-outs during the experiment (presence of too large rounding off error).

In accordance with the passport of the heat energy meter of type УСТ – 95/1-50-03 value of the scale division of the integrator for the range of heat carrier flow from 0,36 to 72 m^3/h is 0,1 *GJ*. Value of the scale division of the heat carrier amount sensors for the same range of flow is 0,1 m^3.

The maximal absolute read-out error of measuring device is the half of the value of the scale division [2]. It means that for these meters the absolute read-out error of thermal energy measuring is Δ_Q = ± 0,05 *GJ*, heat carrier amount measuring Δ_V = ± 0,05 m^3.

As it was said before, the time interval, which was chosen between read outs was 1 hour. During this period of time the amounts of consumed thermal energy according to the integrators were ΔQ_1 = 0,1 *GJ* and ΔQ_2 = 0,3 *GJ*. The amounts of passed through heat carrier according to sensors were V_1 = 1,1 m^3 and V_2 = 1,8 m^3.

It means that the consumed amount of energy was read out from the first thermal energy meter with the maximal relative error

$$\delta_{1Q} = \frac{0,05}{0,1} \cdot 100\% = 50\%,$$

and the amount of heat carrier passed through the first device was read out with the maximal relative error

$$\delta_{1V} = \frac{0,05}{1,1} \cdot 100\ \% = 4,5\ \%.$$

The same registrations were read out from the second device with maximal relative errors correspondingly

$$\delta_{2Q} = \frac{0,05}{0,3} \cdot 100\ \% = 16,7\ \%,$$

and

$$\delta_{2V} = \frac{0,05}{1,8} \cdot 100\ \% = 2,8\ \%.$$

Consumed amount of energy and amount of heat carrier passed through read outs have no correlation. Because of this the credibility of total read out in whole can be estimated with total relative errors, which can be calculated as root-mean-square of their constituents.

$$\delta_{1\Sigma} = \sqrt{50^2 + 4,5^2} = 50,2\ \%;$$

$$\delta_{2\Sigma} = \sqrt{16,7^2 + 2,8^2} = 16,9\ \%.$$

It is understandable that having such relative errors it is impossible to speak about providing any credibility of read-outs and, correspondingly, it is not correct to make conclusions about usefulness or uselessness of thermal energy meters for commercial usage. To provide the credibility of read-outs relativ errors within the scope, for example, three percent, it is necessary to set a period of time between consecutive read outs, which allows heat energy integrators to count an amount of energy not less than

$$\Delta Q = \frac{\Delta_Q}{\delta_Q} \cdot 100\ \% = \frac{0,05}{3} \cdot 100\ \% = 1,67\,GJ,$$

and sensors to count an amount of heat carrier not less than

$$\Delta V = \frac{\Delta_V}{\delta_V} \cdot 100\ \% = \frac{0,05}{3} \cdot 100\ \% = 1,67\ \text{m}^3.$$

On the whole, there is one very important thing to consider for providing read-outs credibility. The thing is that it is always necessary to set time intervals between consecutive read outs, which provides a difference between registrations not less than . It is possible to suggest a general formula for finding this minimum difference

$$\Delta P = \frac{r}{2\delta_P} \cdot 100\ \%.$$

Here *r* – the division value of the devises sensor, δ_P – the credibility of the read out, which is necessary to achieve (the maximal relative error, which has to be preassigned).

3. Conclusion

Using the suggested model of calculation it is possible to define the minimal necessary difference between consecutive registrations of sensors for providing credibility of read outs. On the basis of this minimal difference it is possible to provide any preassigned credibility (any preassigned magnitude of maximal relative read-out error).

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С. Й. Шаманський. Забезпечення достовірності зчитування показників лічильників

Національний авіаційний університет, просп. Космонавта Комарова, 1, Київ, Україна, 03680
E-mail: Shamanskiy_s_i@mail.ru

Незважаючи на те, що багато вимірювальних приладів зараз працюють дистанційно, все ще залишається значною частина приладів вимірювання витрат та об'ємів ресурсів, показники з яких знімає людина шляхом зчитування з циферблата чи дисплея. Достовірність отриманого результату забезпечується точністю (похибкою) фіксації витрати чи кількості споживаного ресурсу. Похибки при зчитуванні показників виникають з кількох причин. Однією з них є похибка округлення. Суттєві проблеми виникають при необхідності фіксації витрати чи кількості ресурсу протягом короткого проміжку часу. Для забезпечення достовірності зчитування показників будь-яких витратомірів та лічильників кількості спожитого ресурсу запропоновано встановлювати інтервали часу між зчитуваннями, які забезпечать мінімально необхідну різницю в показниках. Для знаходження цієї мінімально необхідної різниці запропоновано розрахункову модель. Використовуючи запропоновану модель, можна забезпечити будь-яку наперед задану достовірність зчитування показників (максимальну відносну похибку).

Ключові слова: вимірювальний пристрій; достовірність; лічильник теплової енергії; повірка; показники лічильника; похибка зчитування показників; споживаний ресурс.

С. И. Шаманский. Обеспечение достоверности считывания показаний счетчиков

Национальный авиационный университет, просп. Космонавта Комарова, 1, Киев, Украина, 03680
E-mail: Shamanskiy_s_i@mail.ru

Несмотря на то, что много измерительных приборов работает сегодня дистанционно, все еще значительной остается часть приборов учета количества и расхода ресурсов, снятие показаний которых производится человеком путем считывания с циферблата или дисплея. Достоверность полученного результата обеспечивается точностью (погрешностью) фиксации расхода или количества потребляемого ресурса. Погрешности при считывании показателей возникают по нескольким причинам. Одна из них – это погрешность округления. Серьезные проблемы возникают при необходимости фиксации расхода или количества в течение короткого промежутка времени. Для обеспечения достоверности считывания показателей любых расходомеров и счетчиков количества предложено устанавливать интервалы времени между считываниями, которые обеспечивают минимально необходимую разницу в показаниях. Для определения этой минимально необходимой разницы предложено модель расчета. Использование предложенной модели позволит обеспечить любую наперед заданную достоверность считывания показателей (максимальную относительную погрешность).

Ключевые слова: достоверность; измерительный прибор; поверка; погрешность считывания показаний; показания счетчика; потребляемый ресурс; счетчик тепловой энергии.

Shamanskyi Sergii. Candidate of technical sciences. Associate professor.
Ecology Department, National Aviation University. Kyiv, Ukraine.
Education: Vinnitsa State Technical University, Vinnitsa, Ukraine (1995).
Research area: improvement of water measuring systems in water supply networks and in sewage systems, improvement of sewage water treatment facilities.
Publications: 40
E-mail: Shamanskiy_s_i@mail.ru