

# A New Portable Instrument for Orifice Geometric Parameters Measurement

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**Abstract** According to statistics, about 90% natural gas flow meters used in America and Canada are orifices. In China, the figure is approximately 85%. As we know there are 8 geometric parameters primarily affect the orifice measurement performance. And in the past, some parameters can be measured by several large instruments in labs, but the others such as upstream edge radius cannot be given the quantitative value. It only estimated by experiences. Now all of the values are obtainable due to the development of the new portable 8 geometric parameters measurement instrument, which make use of the photoelectric induction technology. It is easy to operate and carry. A number of experiments have indicated it is accurate and reliable. Recently we are popularizing the new instrument in the field widely.

**Key word** portable orifice geometric parameter prospect

## Introduction

Presently, about 85 percent of flow meters used in natural gas trade measurement in China are orifices. In North America and Europe, orifices are also popularly used in natural gas measurement. The measurement accuracy of orifice is mainly depended on the reliability of eight geometric parameters. The conventional instruments for orifice geometric parameters measurement are huge and inefficient. Each instrument has only one function. In addition, these huge instruments are very expensive and can not be moved and used in fields. And the upstream edge radius ( $r_k$ ) of orifice is judged by visual check or experiences. It is not feasible.

Recently a new portable instrument for orifice geometric parameters measurement has been developed. It is based on photoelectric principle. The data acquisition and process are accomplished by a computer. The instrument can measure these eight geometric parameters one time. Especially value of the upstream edge radius ( $r_k$ ) of orifice can be gained by it. The configuration of the instrument is very good. And it is small and not heavy, and very convenient to operate and bring to fields. It has been proved that this instrument is efficient and accurate. It improves the measurement technology for orifice geometric parameters and is unique worldwide. This instrument has been

widely used and tested in fields of CNPC and by orifice manufacturers presently with good responses.

## Configuration, function and principle

Portable instrument for orifice parameter measurement is comprised of a mechanical body, a horizontal measurement system, a vertical measurement system, a special measurement microscope, a surface roughness measurement unit, a computer, four mini step electromotor and an air pump. The instrument can realize temperature compensation automatically. It is operated by the computer which processes the data and display the measurement result.

This instrument is mainly applied to parameter measurement of standard orifice plates ( $12.5\text{mm} \leq d \leq 150\text{mm}$ ,  $D < 400\text{mm}$ ). Eight parameters as following can be measured by it: diameter of orifice ( $d$ ), roundness of orifice ( $\Delta d$ ), the thickness of plate ( $E$ ), difference between the values of  $E$  measured at any point of the plate ( $\Delta E$ ), upstream orifice plate-flatness ( $\Delta P$ ), thickness of the orifice ( $e$ ) and upstream edge radius ( $r_k$ ) roughness criterion of upstream surface ( $R_a$ ).

Orifice diameter and roundness are measured by a horizontal displacement sensor and a position sensor and calculated according to equation (1):

$$d = d_0 + \left\{ L_1^2 + \frac{\left[ H^2 + \left( \frac{L_2}{2} \right)^2 - \left( \frac{L_1}{2} \right)^2 \right]^2}{H^2} \right\}^{\frac{1}{2}} \quad (1)$$

Where  $L_1$  and  $L_2$  are the two chords which are above and below the orifice diameter respectively.  $H$  is the distance between  $L_1$  and  $L_2$ .  $d_0$  is the diameter of the position sensor probe head.

A vertical displacement sensor, which is driven by a mini step electromotor, and the vertical measurement system are used to measure  $\Delta P$ ,  $\Delta E$  and  $E$ . The sensor is equipped with a unidirectional and vertical force measurement unit. Then a stable vertical force measurement can be maintained.

A special measurement microscope is designed to accomplish the measurement of the orifice thickness and the upstream edge radius. Optical imaging and measurement without contacting principle are applied.

$R_a$  is measured by using a piezocrystal sensor. The sensor transmits the up and down movement caused by surface roughness to a electric signal. Though signal processing, the computer stores the data and evaluates the surface roughness.

### Measurement uncertainty

$$U_d = 4 \mu\text{m} \quad (K=2.58)$$

$$U_{\Delta d} = 4 \mu\text{m} \quad (K=2.58)$$

$$U_{r_k} = 3. \mu\text{m} \quad (K=2.58)$$

$$U_e = 4 \mu\text{m} \quad (K=2.58)$$

$$U(\Delta p) = 8 \mu\text{m} \quad (K=2.58)$$

$$U_{\Delta E} = 8 \mu\text{m} \quad (K=2.58)$$

$$U_E = 8 \mu\text{m} \quad (K=2.58)$$

### Test results in labs

According to a large number of test results in labs and the analysis of the results, these conclusions can be made: the measurement repeatability error of  $d$  is less than  $1.3 \mu\text{m}$ , the measurement repeatability error of  $\Delta d$  is less than  $1.2 \mu\text{m}$ , the measurement repeatability error of  $e$  is less than  $1.4 \mu\text{m}$ , the measurement

repeatability error of  $r_k$  is less than  $1.3 \mu\text{m}$ , the measurement repeatability error of  $R_a$  is less than  $0.026 \mu\text{m}$ .

### Prospect analyze

Orifices are the most popular flow meters in natural gas flow rate measurement worldwide. According to statistics, about 60% and 85% of natural gas flow meters are orifices abroad and domestically respectively. Though new natural gas flow meters, such as ultrasonic flow meters and turbine meters, are widely used in recent years, orifices will still be in main stream in China in 5 years or so, because orifices are relatively inexpensive, highly accurate and convenient to use for operators in fields.

8 geometric parameters primarily affect the orifice measurement performance in orifice measurement. But each of these conventional instruments just has a single function. And they are inconvenient in field use and can not accomplish the measurement of the orifice upstream edge radius. All these lead a lot of problems in orifice measurement. The new portable 8 geometric parameters measurement instrument has solved these problems. It ensures the high accuracy of orifice geometric parameter measurement and can be used in fields. This portable instrument provides a technological support to orifice monitoring in fields. A number of experiments have indicated it is accurate and reliable. Recently we are popularizing the new instrument in the field widely. It causes a great progress in orifice geometric parameter measurement and improves the measurements transfer system in this field.

From 2001 to 2002, this instrument was popularized in many large oil and gas fields in China. A good response has been obtained. Through analysis of these test data, it can be concluded that this portable instrument is highly accurate, efficient, reliable and has a low operation cost. Both the users and specialists of orifices agree that it is very valuable and has a good prospect in field use.