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FREQUENCY PROCESSING AND TEMPERATURE-PRESSURE COMPENSATION OF THE VORTEX FLOWMETER BASED ON TWO-PHASE FLOW

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Abstract- Aiming at a new type and multi-functional intelligent vortex flowmeter integrating system, which implicates whether it is liquid, gas, steam or the mixture of oil and gas, or in special conditions such as high temperature, high pressure, the medium can be measured intelligently. Especially for mixed media by TPF (Two-phase Flow), such as oil and gas, water vapor, firstly separates the mixed fluid through the gas-liquid separation device, and then rolls up the vortex signal, temperature and pressure of separated fluid into one, and finally a stable and accurate result is obtained by inputting the mixed signal through the integrating system. Thus, the applicability and reliability of the flowmeter can be greatly enhanced, which ensures the authenticity and stability of the measurement data about the fluid.

Index terms: Frequency processing, temperature-pressure compensation, vortex flowmeter, TPF, the integrating system.

I. INTRODUCTION

Measurement, the eye of the industrial production and test, has a long development history. No matter the measurement of residents' water consumption in the era of Caesar or the first piece of evaporative heat distribution meter which be invented by Danes in 1924 [1], or the advanced ultrasonic vortex flowmeter nowadays, the existence and long history of measurement can be found in every corner of the daily life and industrial production. Thus flowmeter can be seen as an important part of metrology industry, which reliability becomes direct standard to judge a product qualified or not.

In recent years, with the development of science and technology, variety of automation equipments appeared. These devices guarantee the reliability of industrial production and save a lot of manpower and material recourses as well [2]. Especially in the area of the flow measurement instrument, it is widely used in every aspect of industry such as electric power, chemical industry, coal, petroleum, medical treatment, agriculture, environmental protection, etc. Whether it is gas, solid or liquid, it will be detected and controlled strictly when involved in the process of fluid medium. Thereby, flowmeter becomes one of the irreplaceable facilities in the industrial engineering application field.

Especially in petroleum and chemical industry, the crude oil is often accompanied by the mixed gas such as natural gas; therefore the accuracy of the measuring volume of the oil and gas is particularly important in the whole process such as mining, transportation, refining processing and marketing. In this way, the flowmeter is the only choice [3]. However, most of the current flowmeter can only measure fluid of single medium. It is helpless for mixed medium such as steam, water vapor and oil fluid, etc. Also some flowmeters cannot measuring stably and reflect the real traffic.

It is well-known that the core link in detecting fluid flow contains that the pulse signal through processing the signal produced by fluid is inputted to the CPU integrating system to make frequency stabilization and to the temperature and pressure compensation of pipeline in wall [4].

Therefore, aiming at these shortcomings, such as single function, great error, inadaptation to different environment etc, we can analyze that the reasons include without using the multiphase flow technology, the imperfect integrating system and the external environment factors such as temperature and pressure affecting the measurement result etc.

Facing these problems, we designed a new type of flowmeter and a set of algorithm about signal processing and temperature-pressure compensation in the integrating system for flowmeter, which to make sure that the measured data traffic is stable and close to the real value whether in the face of mixed medium or working under the harsh environment.

II. THE THEORY OF KARMAN VORTEX STREET AND FLOW CALCULATION

a. Karman Vortex Street

As shown in Figure 1, the vortex-generator of triangular prism type is set in the fluid, and the fluid through the vortex-generator's both sides would have alternated two columns of regular vortex. This vortex is referred to as the Karman Vortex Street [1].

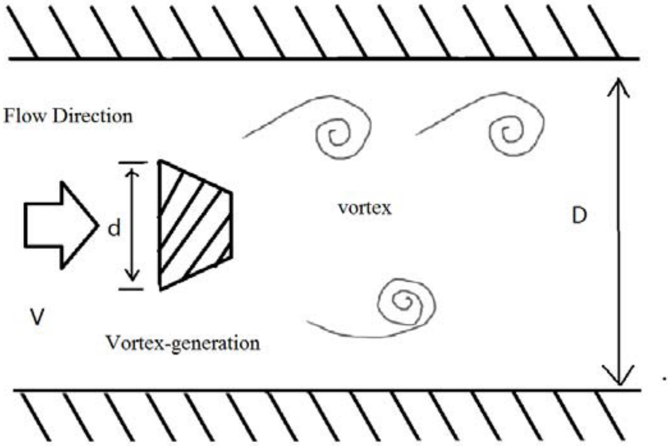

Figure 1. The structural of measurement system

Vortex is arranged asymmetric in vortex-generator's downstream. Assume that the Karman vortex is *f*, the average speed of the measured medium flow is *v*, incident flow surface's width of the vortex-generator is *d*, and pipe inner diameter is *D*. According to the principle of the Karman Vortex Street, the following equation can be got: vortex.

$$f = \frac{St \times v}{d(1 - 1.25\frac{d}{D})} \tag{1}$$

Usually, due to *d* of incident flow surface's width is far smaller than pipe inner diameter *D*, so the Karman Vortex Street can be approximately written as again:

$$f = \frac{St \times v}{d} \tag{2}$$

b. Flow Calculation

Loading a piezoelectric detection probes or capacitance probe after vortex-generator, it can be constituted a piezoelectric capacitance vortex flowmeter. Usually the probe and vortex-generator are composed of metal, so its material properties should also be in consideration. Therefore, we have to pay attention to *St* Number [3]. In the study of unsteady flow or pulsating flow, *St* becomes an important parameter which dimension is *1*. St Number is the ratio of the local migration inertial force and the migration inertia force:

$$St = \frac{lf}{v} \tag{3}$$

In the expression (3) of the algorithm of *St*: *l* is the length of the object characteristics, *v* is the average velocity and *f* is the frequency at the local fluid pulsation frequency. According to different objects of medium, the *St* still has the following formula:

$$St = \varepsilon \mathrm{Re} \tag{4}$$

While ε is medium coefficient, *Re* is Reynolds number in the expression (4), and their relationship is as Figure 2 [8]:

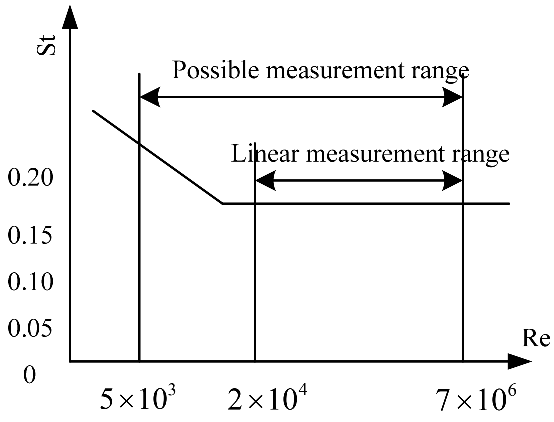

Figure 2. The graph of St's measurement range

Through the above graph, we can see clearly that Karman vortices is proportional to the fluid velocity when the straight part in $St \approx 0.17$ [9], which means that the straight part is linear measurement range for vortex flowmeter. Therefore, we can get the volume or quality through the fluid as long as detecting the Karman vortices.

$$\begin{cases} Q = 3600 \times \dfrac{f}{K} \\ \quad OR \\ M = \rho \times 3600 \times \dfrac{f}{K} \end{cases} \tag{5}$$

Q is the volume of fluid flow (m^3/h), M is the quality of the fluid flow (kg/h), ρ is the density of the fluid flow (kg/m^3), K is instrument coefficient (K-factor) ($1/m^3$).

III. THE ANALYSIS OF K

Instrument coefficient-K of vortex flowmeter is mainly depended on the geometry size, such as incident flow surface width d of the vortex occurred and pipe diameter d, etc. Instrument coefficient-K is the release frequency which through the vortex-generator which in the flowmeter per unit volume, and the unit of instrument coefficient-K can be expressed as: $1/m^3$.

$$K = \frac{3600f}{Q} \tag{6}$$

As we all know, the flowmeter is used to measure the rate of flow of fluid, so if measuring, displaying or analyzing the flow, we could find that the release of the vortex frequency is proportional to the volume of flow fluid as long as K is a constant [10]. Therefore, how to determine the K becomes the primary thing which we have to consider. The following formula is K:

$$K = \frac{4St}{\pi D^2 \beta d} \tag{7}$$

$$\beta = \frac{S_d}{S_D} = \frac{v}{v_1} \tag{8}$$

In this formula, S_d is the cross-sectional flow area on vortex-generator's both sides, S_D is the cross-sectional flow area inside the pipe, v is the average velocity inside of the pipe, and v_1 is the average velocity of flow on vortex-generator's both sides.

Therefore, β, D, d are determined as long as the pipe diameter is determined, so we can get the connection between K and St: $K \propto St$. At the same time, there is a close relationship between average velocity inside of the pipe and constancy of St [8, 9].

According to the Figure 2, we know that there is also a relationship between principles of Reynolds number about the fluid flow condition inside the pipe and *St*. If the density of the fluid flows is ρ , the average velocity inside of the pipe is *v*, and the fluid's viscosity coefficient inside of the pipe is μ , then getting the expression about *Re* as follows:

$$\mathrm{Re} = \frac{\rho v D}{\mu} \tag{9}$$

Therefore, as an important parameter of describing the state of the fluid, *Re* and the vortex show their relations in the following Table 1.

Table 1: Reynolds number-Re relations with vortex

Re	**Flow State**	**Vortex Street**	**St**	$Q \propto f$
$\mathrm{Re} \le 2300$	Laminar Flow	None	None	None
$2300 < \mathrm{Re} \le 2\times10^4$	Transition Layer	Non-steady	Non-constant	Non-linear
$\mathrm{Re} > 2\times10^4$	Turbulent Flow	Steady	Constant	Linear

From the above, we can know that the instrument coefficient *K* is influenced by Pipeline size, vortex-generator size, velocity of fluid, and viscosity of fluid, but it can be affected directly by a combination of these parameters- *Re*. Only when the $Re > 2\times 10^4$, fluid flow and the vortex street are stable, and St is constant, traffic *Q* and Karman vortices *f* become a linear relationship [11]. Combined with Figure 2, Karman vortices are proportional to the fluid velocity when the straight part in $St \approx 0.17$ and vortex flowmeter in linear measurement range. The mobility of the flowing about fluid inside of the pipe is stable, and the real traffic can be obtained. Table 2 is the *K* of common pipe diameter, and the parameters are suitable for dry gas; for superheated steam, it must be divided by 3.5 on the basis of the above-mentioned data.

Table 2: Different diameter of *K* about vortex flowmeter

Diameter (mm)	**K** $(1/m^3)$	**Diameter (mm)**	**K** $(1/m^3)$
DN20	139800	DN80	2480
DN25	74160	DN100	1200
DN30	34560	DN150	350

DN40	18100	DN200	150
DN50	9350	DN250	74.5
DN60	3800	DN300	44

IV. FREQUENCY CORRECTION OF THE INTEGRATING SYSTEM

It can constitute a piezoelectric sensor which is used for collecting vortex signal if loading the piezoelectric sensing probes in the vortex generator [5]. Due to the output by the probe is a pair of differential signal charge, aiming at the measurement of fluid flow based on oil and gas, steam and other mixed medium, the signal conditioning process is as shown in Figure 3:

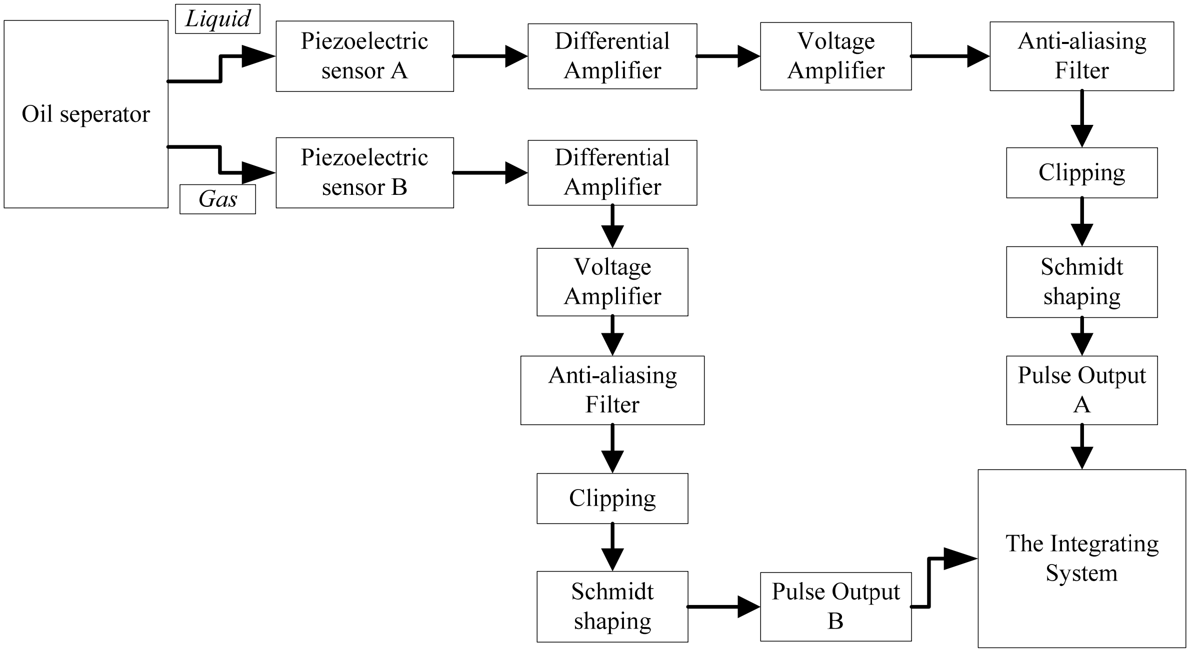

Figure 3. The block diagram about signal conditioning

What we need to do is counting the output pulse by the integrating system and calculating the volume of fluid flow or quality [6]. However, vortex signal is susceptible. If the number of pulses is calculated directly into the formula, the number is volatile, and the standard deviation is larger. Therefore, we should first of all; the number of pulses can be used for fluid flow calculation only after processed in the integrating system. A lot of manufacturers using multi-sample algorithm to estimate the frequency values in current industrial production. The so-called multi-sample is based on the zero - crossing algorithm [12].

a. The principle of Zero-crossing algorithm

The principle of Zero-crossing algorithm is: for sine signal $y = \sin \omega t$, as shown in Figure 4.

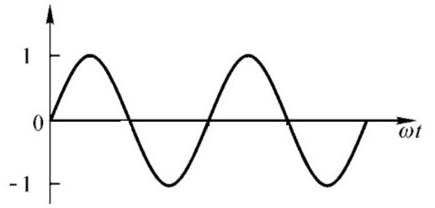

Figure 4. Sine Signal

When ωt is in the process of gradually increasing from *0*, signal amplitude experiences from negative to positive, from positive to negative after a zero point in this process. Thus, four times between the zero-crossing of time T is the cycle of the sine signal when the process of gradually increases from *0*, and the frequency is $f = 1/T$. Assume that the sampling frequency of sine wave is f_S, taking the average value of time between the zero-crossing of the N signal cycle, then calculating the signal frequency, finally the relative error of frequency calculated through algorithm is:

$$\frac{\Delta f}{f} = \frac{\left| f - f' \right|}{f} = \left| \frac{T}{T'} - 1 \right| \tag{10}$$

While f means the actual frequency of sine signal, f' is the sine signal frequency through calculating, Δf is the relative error of frequency, T' is the sine signal periodic through calculating. Among them:

$$T' = T \pm \frac{T_S}{N}, \quad T' = \frac{1}{f'}, \quad T_s = \frac{1}{f_s} \tag{11a, b, c}$$

On the above type, it is apodictic that the error exists. It appears in any process of sample calculation; we can only do our best to reduce error. The larger Nf_s, the smaller the error. So we can increase the sampling points or the sampling frequency [7]. But we know due to sampling theorem:

$$f_s \geq 2 f_{\max} \tag{12}$$

However, the sampling frequency can't be infinite big, usually $f_s = (3 \sim 5) f_{\max}$ is best. Meanwhile, with the increasing sampling frequency, sampling data increases, then system computational cost will increase and the processing time increases; the increase of sampling points-*N* will make the system real-time variation. Measurement data can't reflect the real situation in real time [8]. Therefore, we also consider their advantages and disadvantages while we use Zero-crossing algorithm.

b. Multi-sample algorithm correcting the frequency values

In this paper, based on a zero- crossing algorithm, frequency value estimation will be estimated through multi-sample. Assume that sampling interval is T_S, sampling frequency is $f_s = 1/T_S$, sampling period number is *N*, frequency values of the i cycle count is f_i, frequency values of the j sampling point in the i cycle is f_{ij}, point of the i cycle collected is s_i.

$$f_i = \frac{\sum_{j=1}^{s_i} f_{ij}}{s_i}, i \geq 1, 1 \leq j \leq s_i \tag{13}$$

First of all, comparing in period of frequency values in each period, then getting rid of the maximum and the minimum, this moment f_i is:

$$f_i = \frac{\sum_{j=1}^{s_i - 2} f_{ij}}{s_i - 2}, i \geq 1, 1 \leq j \leq s_i \tag{14}$$

Then calculating the frequency in each cycle and taking the average value, it is concluded that the error of the frequency values is greatly reduced.

$$f = \frac{1}{N} \sum_{i=1}^{N} f_i \tag{15}$$

The above method is applied to that per cycle has the same sampling points. And $s_1 = s_2 = s_3 = s_4 = \cdots = s_i, i \geq 1$.

However, because of the influence of external factors, sampling points of each cycle may not be identical in the actual sampling process. In this case, the method will not be able to reduce the error effectively [13]. Therefore, we first could average the sampling points in *N* periods, and then seek the frequency values. In this way, we can effectively reduce the error, as the following formula:

$$f^{'} = 1/\{T_S[\frac{\sum_{i=1}^{N}(s_i-2)}{N}]\} \tag{16}$$

As a matter of fact, f is closer to the actual value when the velocity stability. In industrial production, as a pair of contradiction, the N value is bigger, the error is smaller; at the same time, the bigger N is, the weaker real-time is. Therefore, N can be appropriated valued bigger for the smooth flow of fluid. But for fluid with excessive change of velocity, N should be taken smaller appropriately. Only in this way, the measured data could reflect the real value better.

V. TEMPERATURE-PRESSURE COMPENSATION

In actual working condition, the vortex flowmeter is mainly used to measure natural gas, steam and other fluid flow, so its cost, accounting and energy-saving index requires higher. However, in the instrument design process of flow measurement, may be because of the large differences of temperature and pressure between the design working condition and the real environment, or different technologies on the instrument production and processing, the measured data of flow cannot be able to truly reflect the actual value [9]. Thus, if we want to guarantee a higher accuracy, we have to make that there is no difference between the working condition of environment and the design values, such as temperature, pressure and so on.

Whether one measured value needed to be modified or not, basically depends on if the density of the medium changes in volatility under various temperature pressures [10]. For gas and steam, their densities are greatly influenced by temperature and pressure. Therefore, in the process of measurement, for the different medium fluid, the measurement results of fluid density are modified when conditions deviate from the design environment [11]. Only in this way, the influence of the measurement results reflects the real value as possible.

Before do the temperature-pressure compensation for fluid, it is first to determine the type of fluid and the process is shown in Figure 5: first to judge whether it is liquid or gas. The liquid could be calculated directly; it should be judged continued if the fluid is gas. Gas is preliminary divided into general gas (dry gas) and steam [12]. Dry gas can be directly as temperature-pressure compensation. In the same way steam could be divided into the saturated steam and superheated steam, and then making pressure for temperature compensations according to different density and types of steam [13].

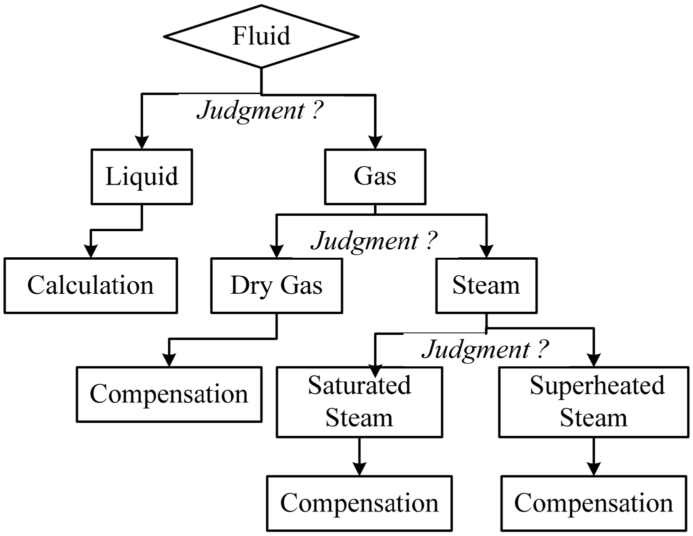

Figure 5. Fluid Discriminate Diagrams

a. Fluid is a liquid

Fluid could be roughly divided into liquid and gas determined by the type of fluid from medium character. As a liquid, its density is almost unaffected by temperature, pressure, thus fluid generally does not need temperature or pressure compensation, Measured values could truly reflect the actual fluid flow, and measured results is fluid volume [14]. According the expression (5), the flow of liquid could be gotten directly.

b. The temperature-pressure compensation of the dry gas

We know from the previous section, fluid could be roughly divided into liquid and gas through the basic state of fluid. The liquid density is almost not affected by temperature and pressure of the external environment [6]. But gas is different while its density is easily influenced by temperature and pressure of the external environment. Therefore, temperature-pressure compensation accounted for a large proportion in the accuracy of the measurement results about gas.

However, vortex flowmeter is not only used to measure the flow rate of the dry gas in industry, but also a large part of them are used to measure flow and quality of steam. Therefore, according to the basic properties of the gas, it could also be divided into general gas (dry gas) and steam. This section will focus on the temperature-pressure compensation of dry gas. In the standard conditions (temperature is $0^{o}C$ (273.15 K) and the pressure is 101.325 KPa (1 the standard atmospheric pressure, 760 mm mercury)) [15], because of the gas flow of the standard $Q_{ST} = 3600 \times f/K$, what's more, gas is influenced by temperature and pressure, mainly on the density of the gas, we can compensate the gas through density. And then make the temperature-pressure compensation for the measured value of gas. So the following is the formula about the compensations about gas's density:

$$\rho = \rho_0 \times \frac{(t_s + T_0)(P_s + P)}{P_0(T + T_0)} \tag{17}$$

While ρ_0 is the density of gas in standard condition, t_s is the temperature of the design, P_s is the pressure of the design, T_0 is absolute temperature (273.15 K), T is the temperature of the working environment , P is the pressure of the working environment, P_0 is the pressure under the standard conditions (101.325 KPa). So the flow of gas after compensations Q_{com} is:

$$Q_{com} = Q_{ST} \times \frac{\rho_0}{\rho} \tag{18}$$

In fact, when designing one flowmeter for dry gas (standard conditions $20^{\circ}C$, 101.325 KPa), the formula on the type could be written again:

$$Q_{com} = Q_{ST} \times \frac{(P + P_0)(t_s + T_0)}{(P_s + P_0)(T + T_0)} = Q_{ST} \times \frac{(P + 101.325)(t_s + 273.15)}{(P_s + 101.325)(T + 273.15)} \tag{19}$$

c. Discriminates of saturated steam and superheated steam

At the scene of the actual measurement, especially in the heating industry, vortex flowmeter is much more applied to the steam flow measurement, while steam can be roughly divided into saturated steam and superheated steam. An inaccurate result of flow measurement is a common problem [16].

When the liquid exists in an airtight container with certain pressure, a part of the liquid will be formed vapor molecules leaving the water due to the evaporation, and a collision with the container wall under the action of thermal motion, then rebound to back again on the liquid surface form special molecules, which becomes the dynamic equilibrium. And saturation state is a coexistence state in the dynamic equilibrium of liquid and gas. Saturated steam is out of steam of the dynamic equilibrium [17].

Continue to constant pressure heating the saturated steam, then saturated steam becomes superheated steam when the temperature of the steam over saturation temperature. For example, critical pressure of water vapor into the steam is 22.129 MPa; the critical temperature is 374.5 ^{o}C. When the external temperature is higher than the critical temperature, the water evaporation of water vapor is superheated steam.

As above, to determine whether a media needed to be compensated or not, determine if the density of the medium is influenced by external temperature and pressure firstly. Also, the first thing is to distinguish that the steam type is saturated steam or superheated steam if we want to compensate for steam. And the standard of discriminate is density checking from the International Steam Table 1976IFC [2]. According to the International Steam Table 1976IFC, the conclusion is that the saturation steam table just has one independent variable: *pressure*; but superheat steam table has two independent variables: *temperature* and *pressure*.

The following is discriminating method: assume that P_0 is pressures determine value, T_0 is saturation temperature, T is the measured temperature of steam, and T' is the temperature value of look-up table. ρ is corresponding the density value of look-up table, ρ_{SAT} is the density of saturated steam, ρ_{SUP} is the density of superheated steam, because of either saturated steam or superheated steam relates to pressure value, then first setting out to P_0 and finding out the corresponding saturation temperature T_0 through a look-up table.

Then judgments that if $T \leq T_0$, the steam is saturated steam, then look-up table that if $T = T'$, and getting that $\rho = \rho_{SAT}$ saturation. If $T > T_0$, the steam is superheated steam, then look-up table that if $T = T'$, and getting that $\rho = \rho_{SUP}$.

d. The temperature-pressure compensation of saturated steam

Usually mass flow is measured when the steam is saturated steam. Through the International Steam Table, the density of saturated vapor is only one independent variable: pressure. Therefore, for the temperature-pressure compensation of saturated steam only conduct pressure compensations. The densitometer formula of saturated steam and steam pressure range shown in the following Table 3, while P is all absolute pressure, $P=P_0+0.10133MPa$, P_0 is the observed pressure of saturated steam .

According to Table 3, based on the pressure range of saturated steam, and combined with the real value, the actual density ρ of steam could be calculated. The standard mass flow calculation formula of saturated steam is: because of the expression of $M_{ST} = \rho_0 \times Q_{ST}$, if ρ_0 is the design of steam density, then we can get the formula:

$$M_{COM} = M_{ST} \times \sqrt{\frac{\rho}{\rho_0}} \tag{20}$$

Table 3: The relationship between densitometer formula of saturated steam and pressure range

Pressure range (MPa)	**Densitometer formula (kg/m^3)**	**Pressure range (MPa)**	**Densitometer formula (kg/m^3)**
0.10——0.32	$\rho = 5.2353P + 0.0816$	1.00——2.00	$\rho = 4.9008P + 0.2465$
0.32——0.70	$\rho = 5.0221P + 0.151$	2.00——2.60	$\rho = 4.9262P + 0.1992$
0.70——1.00	$\rho = 4.9283P + 0.2173$		

e. The temperature-pressure compensation of superheated steam

The same mass flow is measured when the steam is superheated steam. Through the schedule, the density of superheated steam has the two independent variables: temperature and pressure. Therefore, we need to consider the temperature and pressure at the actual situation at the same time for the temperature-pressure compensation of superheated steam. Similarly, the superheated steam of compensations of gas for the temperature-pressure compensation firstly embodies in its density. According to use different fitting formula for the density compensations, the current density values can be calculated through the temperature and pressure measured at the actual situation in real-time. While P_0 is the pressure of the working environment, T is the temperature of the working environment. Usually use the formula is following:

$$\rho = \frac{18.56P_0}{0.01T + 1.66 - (0.0001T + 0.02)P_0} \tag{21}$$

When the actual conditions of steam within $P_0 \in (0.1\ ,\ 1.1)MPa$, $T \in (160\ ,\ 410)^oC$, the compensations formula about density of superheated steam which be tested is:

$$\rho = \frac{18.56P_0}{0.01T - 0.05608P_0 + 1.66} \tag{22}$$

When the actual conditions of steam within $P_0 \in (1\ ,\ 14.7)MPa$, $T \in (400\ ,\ 500)^oC$, the compensations formula about density of superheated steam which be tested is:

$$\rho = \frac{19.44P_0}{0.01T - 0.151P_0 + 2.1627} \tag{23}$$

If ρ_0 is the density of the measured steam design, ρ is the density of steam after compensations, superheated steam mass flow compensations formula is still:

$$M_{COM} = M_{ST} \times \sqrt{\frac{\rho}{\rho_0}} = \rho_0 \times 3600 \times \frac{f}{K} \tag{24}$$

VI. EXPERIMENT

From the last to know, according to different diameter of the fluid, we can judge the effectiveness of the proposed algorithm through the data from the experiments under different conditions. Table 4 is the part of the theory of data in a gas. Then on account of the 25 mm in diameter *D* pipeline under different condition of experiment, the results are as follows:

Table 4: A part of the theory of data in a gas

D (mm)	**K ($1/m^3$)**	**T (^oC)**	**P (MPa)**	**f (Hz)**	**Q (m^3/h)**
20	139800	20	0.10133	252	6.49
25	74160	20	0.10133	210	10.19
30	34560	20	0.10133	189	19.69

a.i When D = 25 mm, and K is 74160 ($1/m^3$) , T = 20 ^oC and P = 0.10133 MPa, then the actual measured values of frequency and flow in different time are as Figure 6.

a.ii At the same time, $D = 25$ mm, and K is 74160 (1/m^3) , $T = 20$ ^{o}C and $P = 0.10133$ MPa. But after multi-sample algorithm, the corrected data is as Figure 7.

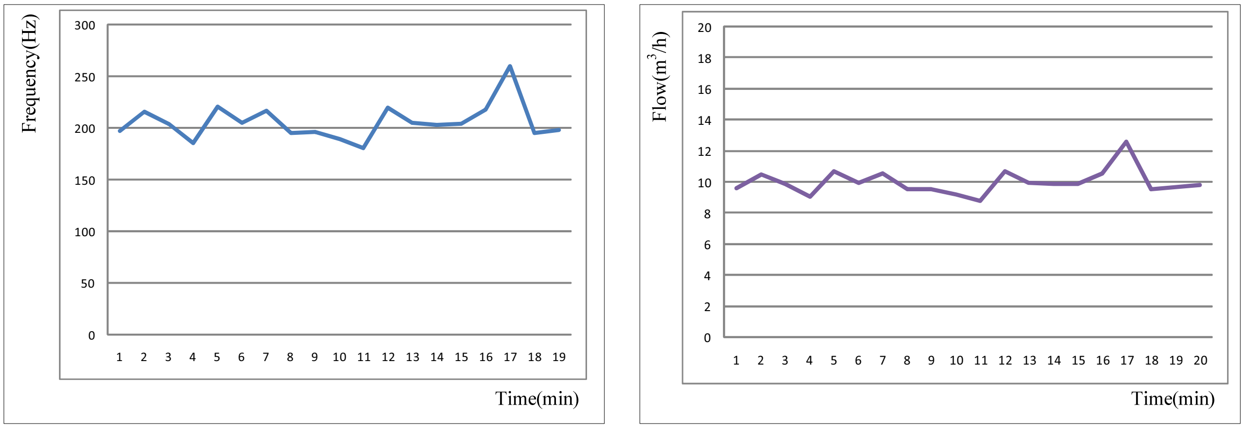

Figure 6. The actual measured values of frequency and flow in different time

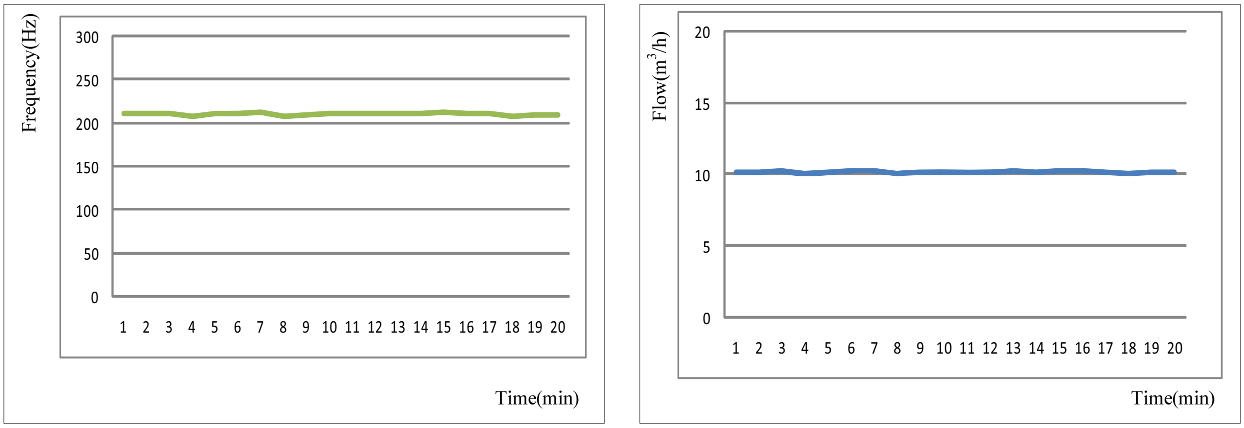

Figure 7. The corrected measured values of frequency and flow in different time

Through the experimental data in above figures, we can see clearly: for a gas, before frequency processing, the measured data is extremely unstable, and floats up and down a lot; but through the algorithm of multipoint sampling frequency in this article, the measured results are quite stable, and fluctuation of data is small.

b.i When D = 25 mm, however, the great changes have been taken place in the temperature and pressure, the actual measured values of frequency and flow are as Figure 8.a, Figure 8.b.

b.ii Similarly, D = 25 mm, however, the great changes have been taken place in the temperature and pressure. However, after temperature-pressure compensation, the corrected values of frequency and flow are as Figure 9.a, Figure 9.b.

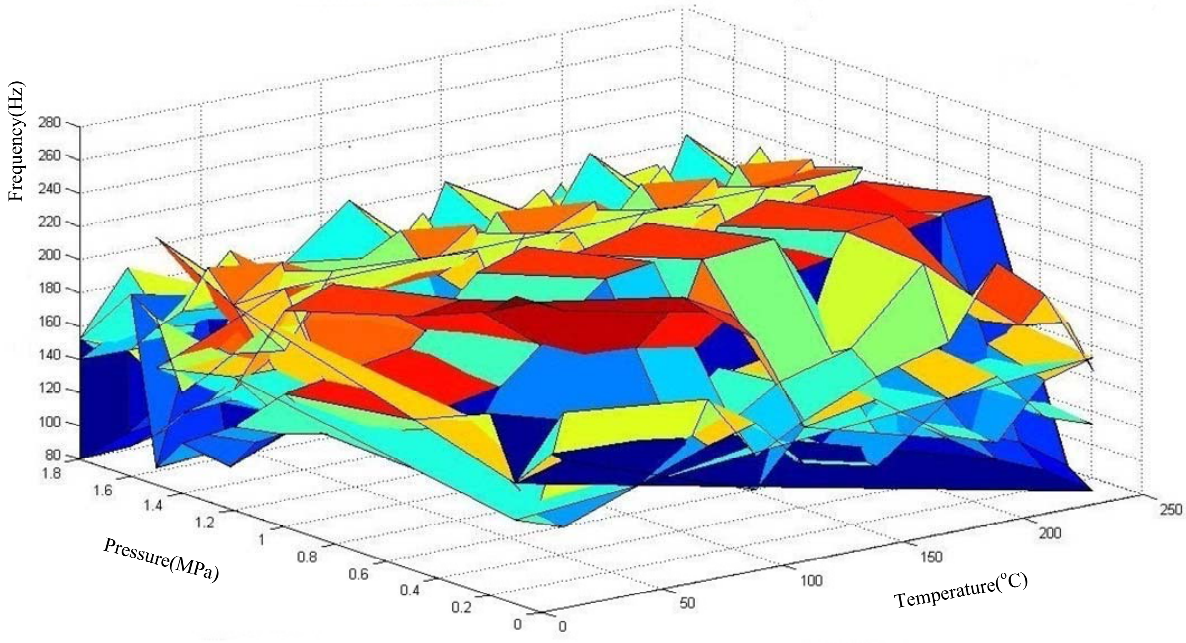

Figure 8.a. The actual measured values of frequency in different working condition

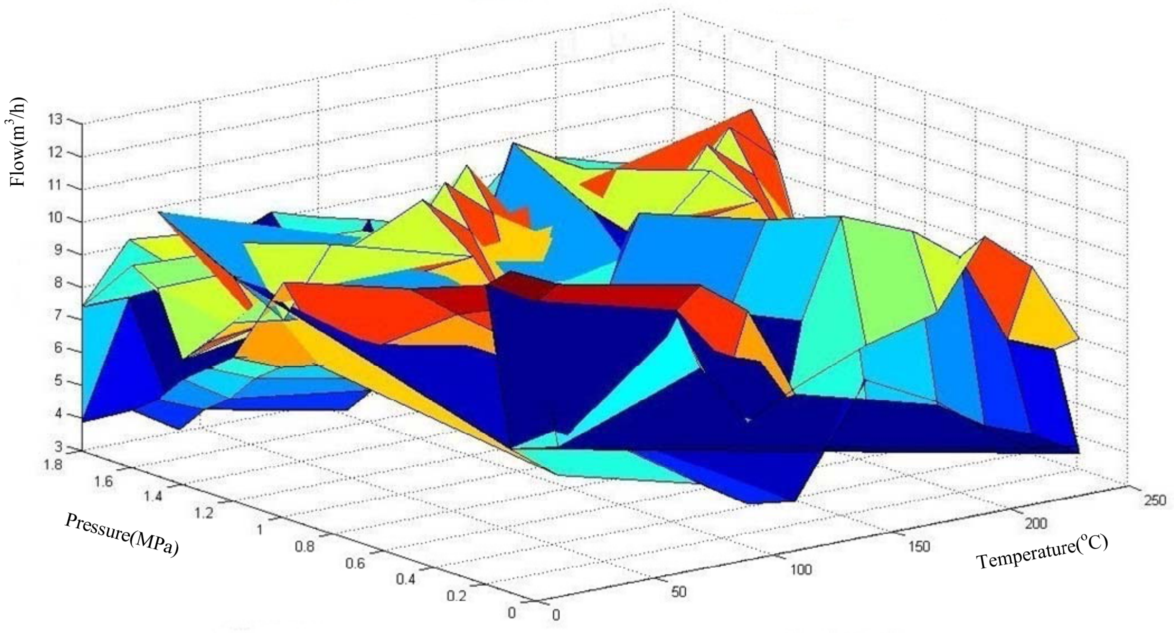

Figure 8.b. The actual measured values of flow in different working condition

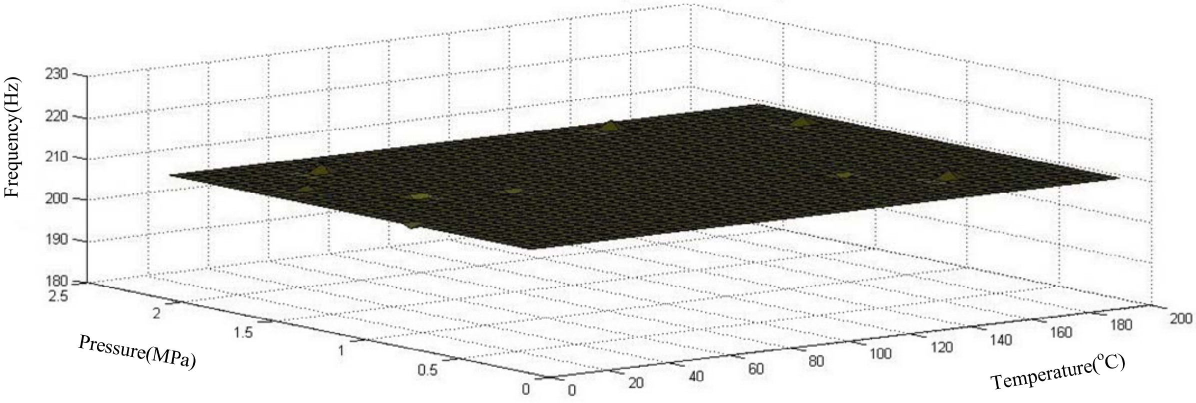

Figure 9.a. The corrected measured values of frequency in different working condition

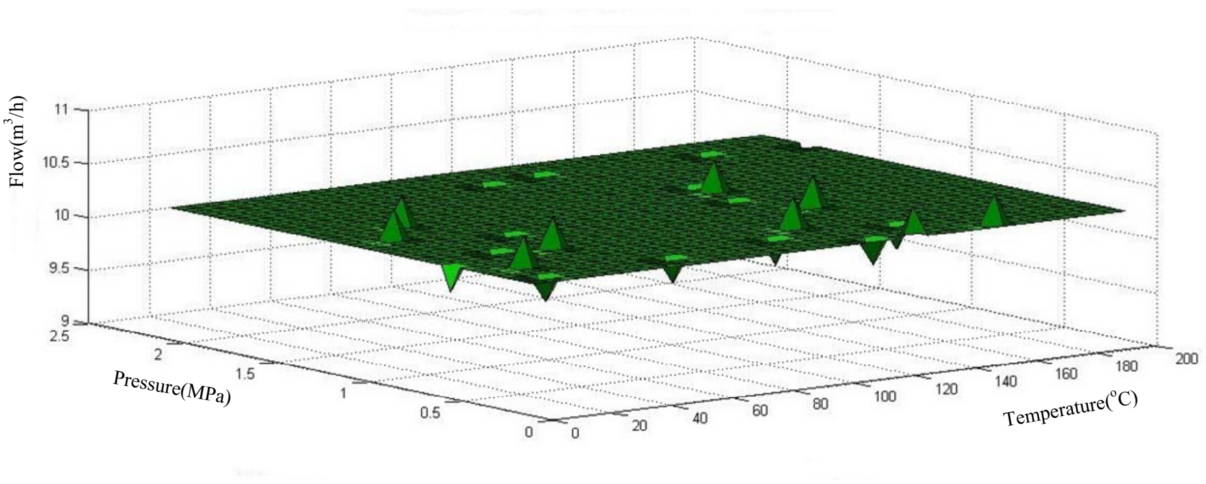

Figure 9.b. The corrected measured values of flow in different working condition

Meanwhile, the measured data floats bigger when the conditions about temperature or pressure change much larger. However, according to different conditions in different medium temperature pressure compensations in this article, whether on the accuracy or in the stability degree, the measured data have been greatly improved.

VII. CONCLUSION

On the basis of TPF (*Two-phase Flow*), vortex street flowmeter is designed to apply the complex environment, and still could get a stable and accuracy measured data. It is necessary to understand different ways of flow measurement fully, and the external influence of the measured results. In integrating system, it is only through means of mathematical treatment to deal with their preliminary measured data to obtain the stable data. In order to obtain the accurate data, the way is to take complex environment of the actual working conditions into consideration and then make temperature-pressure compensation for the preliminary measurement results.

This article is based on these two requirements, analyzing and summing up the process and compensation of a kind of mixed dielectric fluid in different environment, flow measurement results under different conditions, eliminating the error as much as possible, rapidly and accurately getting the fluid flow rate value, which makes the stability and accuracy of the measurement result greatly increased.

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