ISSN:2790-1688 DOI: 10.56028/aetr.1.1.105

Continuously and automatically selecting measurement for production wells with high production and gas-oil ratio

Keke Zhao[1,2], Kun Fang[1,*], Ming Xing[1], Xue Xia[2], Shenghua Jiao[1], Yue Sun[1]

[1] China Petroleum Engineering & Construction Corp. Beijing Company, Beijing, People's Republic of China;

[2] College of Pipeline and Civil Engineering, China University of Petroleum, Qingdao, Shandong, People's Republic of China

*Corresponding author e-mail: 827574648@qq.com

Abstract. To meet the requirements of large-scale and fast production, conventional metering technology will fail in the production well with high production and gas-oil ratio. In this paper, we propose a high degree of automation, unattended, continuously and automatically selecting measurement system, which is mainly consisted of automatic selecting system, continuous metering system, and Remote Terminal Unit(RTU) control system. This continuously automatic metering system has many advantages, such as wide measurement range, high automation, short inversion time, and high measurement accuracy. It has been successfully applied in an oil field metering station in the Middle East, and has achieved good performance. We expect that its extensive promotion will benefit the digitization and automation of future oilfield production.

Keywords: International oilfield; automatic selection; continuous metering; digitization.

1. Introduction

During the oilfield surface production process, in order to facilitate production management and data acquisition, the wellhead fluids production, such as oil or gas from a certain single well, will be detected and measured before importing to the Central Processing Facilities. So single-well metering is the regular process technology in oilfield surface engineering. Traditional single well metering methods are widely used for oilfields of low production and small gas-oil ratio, which, however, have many disadvantages including low degree of automation, low measurement accuracy, narrow measurement range, etc.. For oilfields of large single-well yield and large gas-oil ratio, such as the Hafaya Oilfield in the Middle East of single-well yield up to 6000 BOPD and gas-oil ratio up to 3000 SCF/STB, conventional metering technology will fail. Therefore, the traditional Oil Gathering Manifold (OGM) metering technology could not meet the requirements, and there is an urgent need to develop a continuous automatic selection of well fluids metering technology. Here we propose a continuously automatic metering system, which has been successfully applied in an oil field metering station in the Middle East.

2. Another section of your paper

As shown in Fig. 1, we propose a continuously automatic wellhead selection system, which includes an automatic wellhead selecting system, a continuous metering system, and an RTU control system. The specific workflow is:

ISSN:2790-1688 DOI: 10.56028/aetr.1.1.105

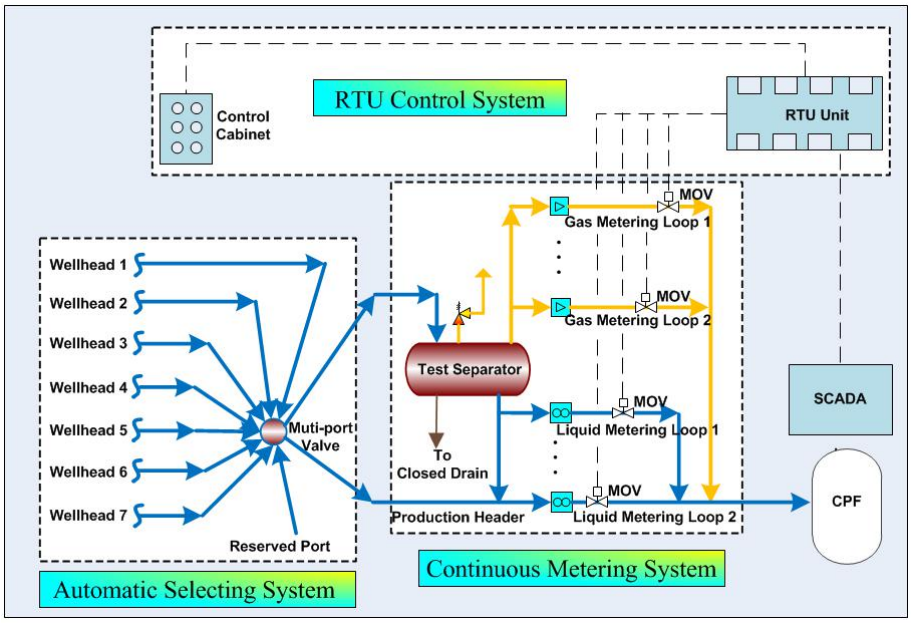

Figure 1. Well selection and metering chart.

RTU: Remote Terminal Unit, SCADA: Supervisory Control And Data Acquisition,
CPF: Central Processing Facility.

(1) The well fluid flows to Multiport Selecting Valve, which normally has seven valve cores;

(2) The RTU control system indicates the electrical actuator rotating the valve core to face the inlet of wellhead to be metered, thus the selected well fluid flows to Two Phase Separator;

(3) After the separation of gas and liquid phase, the gas is automatically switched to the matching gas phase pattern loop for metering, and the liquid is automatically switched to the matching liquid phase pattern loop for metering;

(4) The gas and liquid are mixed again and flow into the Production Header together with each other;

(5) The Test Separator begins to discharge the fluid to the Closed Drain Drum;

(6) When liquid lever of Test Separator reaches a setting low value, the next single well would be shifted to the metering line. Thus the "continuous" and "automatic" measurement of single well fluids is finally achieved.

The working principle and function of the three subsystems are described in details below.

2.1 Automatic selecting system

As shown in Table 1, there are mainly three metering station construction models of oil fields, that is, all manual operation metering stations, automatic metering stations basing on electric three-port valve, and automatic metering stations basing on electric multi-port valve. All manual operating metering station requires artificial manual shift to introduce a single well fluid that needs to be measured into the metering line. The metering station based on electric three-port valve changes the manual inverting to the electric three-port valve automatically selecting the well, but needs large area and high maintenance workload. The metering station based on electric multi-port valve selects well automatically through electric multi-port valve, which covers a small area and is easy to operate, thus it can meet unattended requirements. For some certain oilfield areas, where the social situation is unstable and/or the human resources is short, the multi-port valve selection automatic metering station is favored, considering its the advantages of highly automation, and the maintenance and operation convenience.

ISSN:2790-1688 DOI: 10.56028/aetr.1.1.105

Table 1. OGM construction models

Group By	Manually operated metering station	Automatic measuring station (Electric three-port valve)	Automatic measuring station (Electric multi-port valve)
Feature	Requires shifting well manually	Needs large area and high maintenance workload	A small area, easy to operate

With the electric multi-port valve selection mode, single well selection and measurement could be set and controlled at the RTU unit, and the data collected by the RTU needs to be uploaded to the SCADA system for centralized monitoring. It works as follows: the well fluid enters the multi-port valve skid, and the multi-port valve is driven by the electric / manual actuator. When the valve core port is rotated to face the inlet line of selected well, fluid from the selected well flows into the metering line by multi-port valve and fluid from the other oil wells will gather in the multi-port valve, and finally enters the production pipeline [1]. Once the measurement is completed, RTU system issues a signal to start the electric actuator motor, and controls the valve core to rotate to the inlet line of next well to be measured, thus ensuring continuous metering. Before the metering of the next well, the test separator is automatically discharged, that is, when the fluid level of separator reaches a low value from the normal value, the next single well fluid enters the test separator. And the previous metering steps repeat. The cycle of the rotation meter is 2 hours, which is sufficient to empty the upper single well residues in the test separator completely and to reduce the return between the single-well fluids.

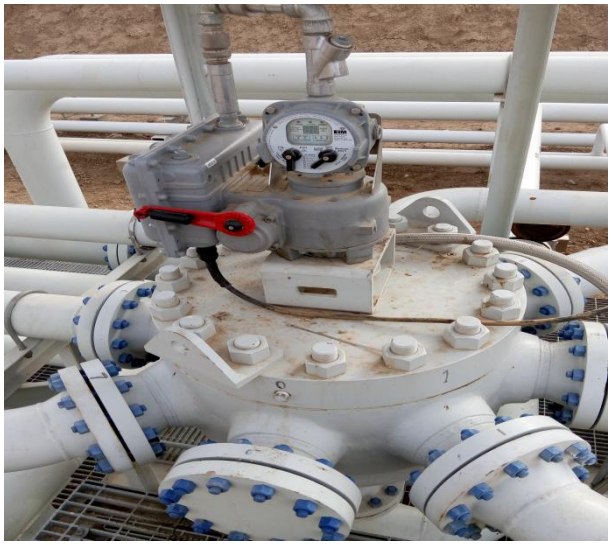

Figure 2. On-site photo of an eight-port valve

The most widely used is eight-port valve [2], whose valve body contains eight inlets and two outlets. Typically it could connect seven production wells, and one empty port is reserved for temporary maintenance or for flushing, which can also guarantee that all well port fluids enter the production head during non-metering period. When the measured well number is more than eight, it takes two (or more) multi-pass valve severing in parallel, and the maximum connecting well number of each multi-port valve is still seven, that is, all the remaining multi-port valves should correspond to the null valve position while one multi-port valve is on metering.

2.2 Continuous Metering System

For the oilfields of high production and large range span of single wells, one single metering instrument does not meet the measurement accuracy. So the gas phase metering and liquid phase metering both adopt double-loop of large measuring range and small measuring range. If the range

ISSN:2790-1688 DOI: 10.56028/aetr.1.1.105
selection requires manual handover, it will not realize continuously automatic metering, nor meet unattended requirements.

In this paper, we propose a continuous metering method, which contains at least two gas phase measuring ranges and at least two liquid phase measuring ranges, and all the metering loops are equipped with a Motor Operated Valve(MOV) and access the RTU control system. Firstly, a suitable loop is selected according to the predicted production capacity of the well to be measured, and the predicted capacity can be a liquid production or a gas-oil ratio. Secondly, the switch of MOV valve on the metering loop selected in the first step is controlled according to the data measured by the flow meter. If the flow value is between its setting ranges, the meter reading is considered as the flow rate of this well fluid. Otherwise, the MOV valve is turned off, and the other loop MOV valve is opened, thus the well fluid is automatically switched to another loop. Repeat the above steps until the well production is in the range of a measurement loop. It can be permitted that the range of gas phases or liquid phases has a portion of the range between different routings of the loop, to avoid that small changes in gas or crude oil production cause frequent switches of the MOV valve, and the spans of each meter range can be the same to each other, with the specific range being set according to actual needs. After measurements, the above gas and liquid fluid are mixed to the production header. In addition, when the MOV valve failure or during maintenance, the metering system can also be manually switched to select the appropriate range of routines in the central control room to ensure normal production and measurement.

2.3 RTU Control System

RTU Control System [3] [4] is an independent data acquisition and control unit that supports communication between the SCADA Control Center and the field devices. It controls sites and obtains data remotely and passes the data to the control center of SCADA system. Its security and reliability is especially important.

The role of RTU Control System in this continuously automatic metering device is mainly reflected in the following three aspects:

(1) Select the target single well by setting the RTU operating tray. RTU system transmits the signal to the control cabinet next to the multi-port valve through the signal line. The signal controls the rotation of the multipart valve to ensure that the inlet of multi-port valve connects to the pipeline of the selected well. Thus remotely intelligent automatic selection is achieved.

(2) Control the switch of the MOV valve in each measurement loop automatically according to the real-measured data. If the flow value is in the range of the loop, no action would be performed, otherwise the MOV valve would be turned off and the other loop MOV valve would be opened until the single well yield matches the range of measurement loops. In addition, this MOV valve can be operated by the RTU system remotely, or by the electric actuator on the site. The switch state of the MOV valve needs to be uploaded to the RTU system, followed by being transferred to the SCADA system.

(3) Drain the liquid remaining in the test separator automatically before the switch of different wells. That is, the next well is switched to after the separator liquid level is reduced from the normal value to the low value, thereby avoiding back mixing of fluids from different wells.

3. Field application examples

This continuously automatic metering system has been successfully applied in a certain oilfield metering station in the Middle East. The measured yield of the single well ranges from 100-9500 BLPD（0.66-62.9 Nm3/h） and the gas-oil ratio range is 540-1000 SCF / STB（96-178 m3/ m3）. The selected well fluid is imported from the top of the test separator through the multi-port valve outlet, and then separated to be two phases of oil and gas for measuring separately. According to the selected well production range, two loops are set respectively for liquid phase and gas phase. The overall range covers all predictive capacity values of all connected wells, and there are intersections

ISSN:2790-1688 DOI: 10.56028/aetr.1.1.105
between large and small ranges. For liquid phase, the large-scale loop can determine the liquid production range of 1167-11210 Nm3/h, the small-scale loop can measure the liquid yield range of 64-1300 Nm3/h. For gas phase, the large-scale loop can measure 6.6-62.9 m3 / h, and the small-scale loop can measure 0.66-13.2 m3 / h.

Figure 3. On-site photo of a continuously automatic metering system in a certain oilfield metering station in the Middle East.

We first select a suitable metering loop according to the predicted production capacity of the well. Here, it assumed that the small range for liquid phase (64-1300 Nm3/h) is selected. If the flow value happens to be between 64-1300 Nm3/h / h, then the instrument reading is considered as the flow rate of this well fluid. Otherwise, the MOV valve is turned off, and the large-scale circuit MOV valve is opened, thus the well fluid is automatically switched to large range loop (707-11210 Nm3/h). If the MOV valve fails or during maintenance, it is permitted to be manually switched to the appropriate range loop in the central control room. Two Pressure Valve (PV) are provided on the two loops of gas phase, which controls the stabilization pressure of the test separator in the normal value. Two Liquid Valve (LV) are provided on the two loops of liquid phase, which controls the liquid level in the test separator to be stable in normal. The next single well fluid would not enter the test separator until the test separator level is reduced to low value. After measurement, the gas and liquid fluid mentioned above are mixed to the production header.

4. Conclusion

Measurement of wellhead fluid is crucial for dynamic analysis of production and real-time adaptation solutions. For oilfields of high productivity and large gas-oil ratio, we propose the continuously automatic selection metering method, which can be well applied worldwide. Besides, this method meets the unattended requirements. The characteristics of this method are summarized as follows:

(1) Applicable to a wide range of single well productivity. The measurements of gas phase and liquid phase both have one large range metering loop and one small range metering loop. The overall measurement range can covered all oilfield wells' productivity.

(2) High degree of automation. Our method selects well automatically through multi-port valve, and chooses a suitable measurement loop according to the predicted yield. Thus continuous and automatic measurement is achieved, especially appropriate for single-well metering of giant oilfields.

(3) Short inversion time and high measurement accuracy. By draining the fluid of test separator until to the low liquid lever before the next well fluid entrances, the back mixing of different well

ISSN:2790-1688 DOI: 10.56028/aetr.1.1.105
fluids is thus reduced and the accuracy is improved, while the time of different single well inversion is shortened.

Digitalization and automation is an inevitable development trend of future oil field production and measurement, which can effectively improve labor efficiency, reduce workers' labor intensity, improve oil and gas production management level, especially for regionally safe risk, can reduce the risk of on-site operations. At present, the continuous automatic metering system has been successfully applied to a certain oil field in the Middle East, and has achieved good results. Its extensive promotion will help to fully realize the digitalization and automation of future wells.

References

[1] Wang Zuyuan, Zhang Ji. Assign metering multi-port valve technical analysis, J. Fluid Machinery. 35 (9) (2007) 41-43.

[2] Jiang Jiansheng. Application of multi-port valve selective technology in intelligent oilfield measurement station, J. Journal of Liaoning Petrochemical University. 34 (1) (2014) 69-73.

[3] Zhao Caixian. Planning and research on the control system of the whole oil field, J. Instrumentation Users. 27 (11) (2020) 1-4.

[4] Ren Jian. Application of data acquisition and monitoring technology in digital oilfield construction, J. Chemical Management. 15 (79) (2021)161-162.