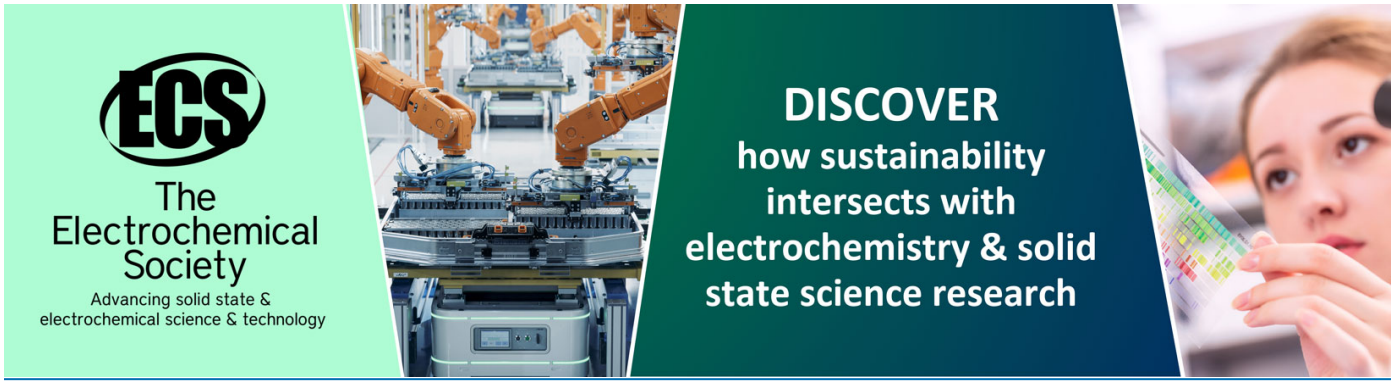
Analysis of Automatic Metering for Oil Storage Tank



Analysis of Automatic Metering for Oil Storage Tank

Sun Wei

IoT Research Center, China Electronics Standardization Institute, 1 Andingmen East St, Dongcheng District, Beijing, China

Abstract. This paper summarizes the comparison of tank metering methods and automatic metering methods, combined with the typical cases of radar level meter and servo level meter in engineering by E+H Company.

1. Introduction

Oil depot is the link to coordinate crude oil producing, processing, oil supply and transportation, which main function concentrates on oil products load/unload, transport and store. The measurement and management of oil products is the critical part of oil storage and unloading, thus to some extent, the accuracy of tank level gauge determines the level of metering management of oil depot.

At present, oil tank metering methods mainly divided into two categories, one is manual metering method, which is, carried out by means of measuring ruler and level meter. This measurement method is simple and easy to use, however as well as being time consuming and labor intensive, it is also limited by data reading error. For a long time, petroleum products have been measured by artificial volume, and the corresponding calculation criterion of volume and mass provided by the national standard GB/T 1885-1998 is the main conversion method. In large and medium-scale oil depots, operator carries out manual metering every certain cycle. The other is indirect metering, which uses relevant data collected by sensors including temperature, pressure, etc. In recent years, with the continuous progress of automatic metering technology and the rapid growth of the oil depots storage capacity, many oil depots have gradually use automatic level gauging systems in the consideration of reducing costs and increasing efficiency. The automatic metering system has become an important means to improve the technical management level of oil depot and standardize the management of oil product.

Generally speaking, three types of tank automatic metering systems exist as mainstream, which is liquid level method (ATG system), static pressure method (HTG system) and hybrid method (HTMS system) specifically. Traditionally, people used to estimate the tank automatic metering system accuracy by relative error. China's trade handover measurement is mainly based on two standards, JJG1014-89, Technical Specification for Measurement of liquid Petroleum Products in Tanks, and SYL01-83, Specification for Measuring Vertical Metal Tanks of liquid Petroleum Products. When the handover volume is not less than 25% of the total tank capacity, Relative error of quality measurement (relative error between real value and measurement value) less than 0.35% is acceptable.

2. Analysis of liquid level Measurement method

Liquid level method is a method based on liquid level and temperature measurement. The main measuring instruments are liquid level transmitter, oil temperature transmitter, etc. The measurement parameters of liquid level metering system include oil temperature, oil level, water level and manual sampling density. According to the direct measurement parameters, the tank volume table and the

petroleum meter, the oil product volume and the oil product quality can be obtained, and the calculation process of the indirect measurement parameters in the tank is shown in the diagram. The liquid level method can not measure the density parameter of oil product automatically because the pressure parameter of liquid column is unknown. The other parameters of oil product in tank can only be obtained by manual measurement or calculation. The quality of oil must be calculated by formula.

$$M = V_{20} \times \rho_{20} \tag{1}$$

If air buoyancy is taken into account, then

$$M = V_{20} \times (\rho_{20} - 0.0011) \tag{2}$$

In the form:
M—Oil Mass;
V_{20} —Oil Volume;
ρ_{20}—Standard Oil Density.
Due to the density error of manual measurement, as well as some certain density value can only be partially obtained, it is difficult to collect the accurate average density, and lead to high mass error.

3. Static Pressure Measuring method

With the use of high-precision intelligent digital pressure transmitter, hydrostatic pressure measurement method is rising gradually.

The measuring principle of static pressure method is to measure the liquid pressure by pressure sensor P1 which is installed at the bottom of the tank. Then according to the size of the tank section area, that the oil quality in the tank can be calculated.P2 is a pressure sensor mounted 3m above the P1, mainly used to measure the density. P3 is a pressure sensor installed on the top of the tank. Its main function is to measure the pressure of the oil and gas mixture in the tank, which is suitable for the sealed dome tank, while the inner floating roof tank does not need to use P3, because P3 is equal to the atmospheric pressure. The calculation methods of each parameter are as follows:

$$M = A \times (P1 - P3) \tag{3}$$

$$\rho = (P1 - P2) / (H2 - H1) \times g \tag{4}$$

$$H = (P1 - P3) / g \times \rho + H1 \tag{5}$$

In the form:
M—Oil Mass;
A—Average Sectional Area;
H—Oil Level;
ρ—Petroleum Actual Density;
P1—Tank Bottom Pressure;
P2—Tank Upper Part Pressure;
P2—Tank Top Pressure;
H1—P1 Installation Height;
H2—P2 Installation Height.
It can be seen from the above formula that all these parameters are obtained by the sensor without any manual measurement value, so the error of manual measurement is eliminated. The measurement method is based on the National Metrological Verification Regulation of the People's Republic of China (JJG759-97) "Hydrostatic Oil Tank Measuring Device". The features of static pressure measurement include:

1) High Oil quality measurement accuracy. This is because the quality of the oil is measured directly by the bottom pressure sensor, which is independent of the change of the parameters such as density and temperature, so it is not affected by the error of these parameters.

2) High error rate of liquid level. The liquid level is slightly lower than the real liquid level because the liquid level is inversely deduced from the density, and the density is slightly larger than the average density of the liquid in the tank.

3) The mass data by static pressure method is obtained by the bottom static pressure times the effective cross section area of the tank, so long as the pressure is calculated and measured, then the measurement of mass can be measured. These measured pressure data are traceable, so this method is more reliable for tank metering, but the static pressure method is limited by the installation position of pressure instruments.

4. Mixed measurement method

The mixing method is a combination of the level metering method and the static pressure method. The main measuring instruments are level gauge, pressure sensor and oil temperature sensor. The measurement parameters of mixed metering system mainly include oil level, water level, oil temperature, bottom oil pressure and top oil pressure. The average temperature, apparent volume, standard volume, apparent density, standard density and mass of the oil products were calculated according to the measurement parameters, the tank volume table and the petroleum meter.

The mixed metering can not only measure the oil level and water level, track and monitor the oil in and out, but also improve the accuracy of the whole system by calculating the density of the measuring parameters of the liquid level meter directly.

The measuring principle of mixing method is that the real liquid level in the tank is directly measured by the level gauge installed in the tank, the liquid pressure is measured by the pressure sensor installed at the bottom, and the mass of the liquid in the tank is obtained by calculating the mass of the liquid in the tank.

$$M = A \times (P1 - P3) \tag{6}$$

$$\rho = (P1 - P3) / (H - H1) \times g \tag{7}$$

In the form:

M—Oil Mass;

ρ—Petroleum Average Density;

P1—Tank Bottom Pressure;

P2—Tank Top Pressure;

H1—P1 Installation Height.

It can be seen from the measurement principle of the mixed method and the calculation of each parameter that the accuracy of the measurement of liquid level mass and density is relatively high, so it is an ideal metering method. Compared with other methods of measurement, the hybrid method has the following advantages:

1) High precision density measurement for continuous liquid storage;

2) It is helpful to set up a fully functional storage tank monitoring and management system, reduce the labor intensity of the operators, and improve the entire automation level of the tank area;

3) Multi-parameters can be measured simultaneously;

4) For the application of quality measurement, the side-effect of temperature measurement error is excluded.

5. Typical Case

Taking an international oil storage and transportation depot of Yangshan Port in Shanghai as an example, this paper introduces the system constitution of mixed metering method.

The oil storage tank consists of 60 storage tanks in total, 29 tanks have been built in project phase I. The measuring sensors are mainly E+H servo level meter and high precision radar level meter. According to the characteristics of different media, temperature, pressure and tank type, the corresponding form of level meter is selected. For example, a bell-mouthed antenna radar level meter is installed on a no-guide wave-tube dome, which is suitable for measuring the liquid levels of various petroleum and chemical products other than asphalt and other products; parabolic antenna radar level meters can be installed on a no-guide wave-tube dome tank. It can also be installed on floating roof tanks to measure bitumen, tar and other chemical products. The servo level meter can completely meet the requirement of measuring accuracy for any storage tank in the trade transfer purpose. The composition of the project is shown in the figure 1.

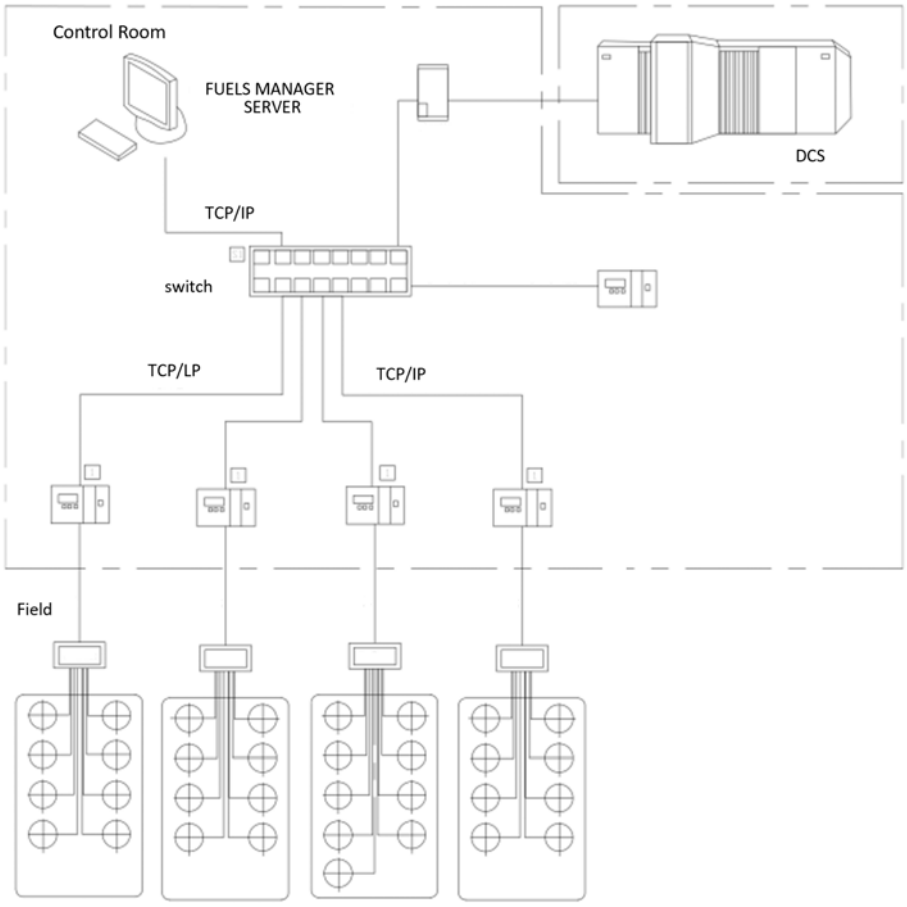


Figure 1. Storage Tank Automatic Metering System Architecture.

In the first phase of the project, due to oil tank type includes dome tank and inner floating roof tank, and the types of petroleum products stored in the tank are different, servo level meter and radar level meter are both adopted in the project. The specific differences in measurement are shown in figure 2 and figure 3.

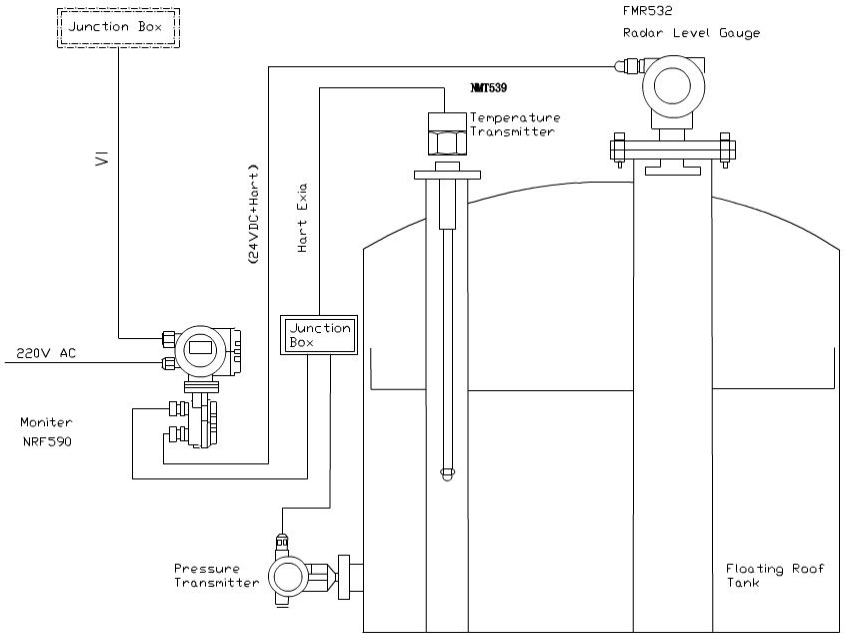


Figure 2. Radar Level Meter Installation.

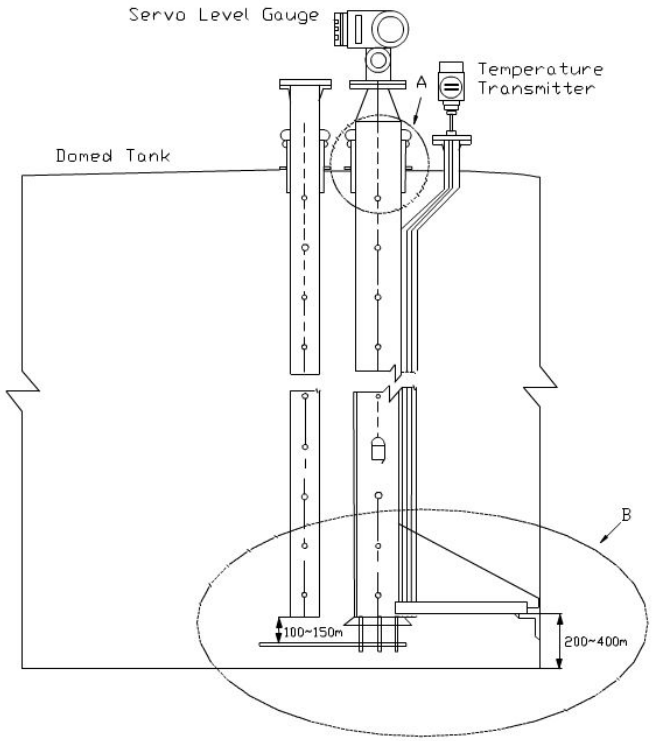


Figure3. Servo Level Meter Installation.

In the project, through the successful deployment of the measurement system, the following functions have been realized:

1) The accurate and reliable level gauge and SCADA system can monitor the oil storage of all oil tanks in real time;

2) The petroleum products flow-in/flow-out condition can be dynamically monitored in stock-in/stock-out stage, and increase or decrease of petroleum product volume rate in the oil tank will be calculated;

3) Timely collect and report the stock-in/stock-out and inventory data, to manage the producing conditions and make rational and scientific scheduling;

4) The staff can set the limit value of liquid level, temperature, pressure, remind to receive, send oil to switch operation, avoid the accident such as taking oil, pumping out in the process;

5) Monitoring the working condition of oil tank and oil pump, and warn the abnormals.

6. Conclusion

As oil prices keep sliding down, in the process of storage and transportation of petroleum products, energy saving, consumption reduces and efficiency improving has become particularly important. More and more attention has been paid to the automatic tank metering system. How to improve the working efficiency and provide centralized, accurate and reliable production process data have become the focus in the petroleum products storage and transportation field.

References

[1] Dong Haifeng, Huang Cen-Yue, Oil Tank Automatic Metering System and Pressure Sensor [J], Petrochemical Technology No. 21 Volume 3

[2] Analysis of Automatic Metering Method for Oil Tank [J], Petroleum Business Technology, 2009.3

[3] Sun Guofeng, How to choose automatic measuring device for Oil Tank [J], Oil and Gas Storage and Transportation No. 5 Volume 18

[4] Application of E+H Tank Measurement system in Oil Tank Metering [J], Industrial Control Computer, No. 9 vol. 23

[5] Lufenlan, Overview of metering Technology in Tank area [J], Guangdong Chemical Industry, 2012.4