The Research of Full Automatic Intelligent Oil Filtering System Based on Flow Totalizer Control

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Abstract. Transformer oil quality has a great impact on the production of UHV; The traditional single tank type or inverted tank type oil filter can be used for transformer oil filter in UHV Substation. The disadvantage of this method is the low degree of automation, high labor costs, error prone and low efficiency. Therefore, the research and application of the automatic intelligent oil filter system has broad prospects. This paper introduces a kind of intelligent oil filtering system based on PLC and configuration software designed to liberate workers on site, reduce error rate and improve production efficiency.

Introduction

State Grid Corporation of China emphasized to deepening the research on grid planning and to speeding up the process of planning and construction of UHV in 2016 work conference. At present, our country has achieved perfect in the field of power transmission from the followers to the leader role conversion. UHV substation main transformers have been completely localization in our country. During the construction of UHV substation in our country, in order to avoid the quality of the transformer oil can’t meet the index requirement of the project, project owner usually need to flow backward cycle transformer oil filter processing. Compared with the single tank filter oil circulation structure, backward cycle oil circulation filter technique dismantled the oil drain on the top of the tank, added the oil tank B into the system, and connected the oil tank A and the oil tank B by the vacuum filter oil machine. Put the transformer oil in the oil tank A into the oil tank B by the vacuum filter oil machine after heating and filtering. When all the oil in the oil tank A drawn into the oil tank B, use the same method to pour the transformer oil in the oil tank B back to the oil tank A by the vacuum filter oil machine after heating and filtering. Repeat this process and make the impurity and the oil out from the unqualified oil until the no-oil, withstand-voltage and other indexes to meet the qualified requirements. But the conventional way of filtering oil is still in a state of pure traditional manual operation. In this process, the disadvantages of large man-powered amount labor, too long time to filter and the difficulty to detect the temperature of the oil, will lead to a low efficiency. This is also not in conformity with the trend of industrial production automation and intelligent.

In order to solve the problem of the large amount of oil, the long processing time, the frequent switching of the filter, the continual testing and the low efficiency in the UHV substation, we need new technology to realize intelligent control transformer oil
filtration in UHV substation. Automatic intelligent oil filter system based on flow
totalizer control in UHV substation can liberate the site staff, achieve the automatic, fast
and continuous detection of the oil with the advantages of real-time display working
state, high precision control, high working efficiency and unnecessarily frequent
start-stop filter oil machine.

**Traditional Oil Filtering Methods and Its Shortcomings**

**Traditional Oil Filtering**

At present, the single tank filter oil circulation technique and backward cycle filter oil
circulating technique is the most common way in UHV substation.

The principle of single tank filter oil circulating technique is as follows:
1. Heat and filter the oil by oil filter;
2. Transport the filtered oil back to the tank by the entrance on the top of the tank;
3. Repeat the step 1 and 2;
4. Keep filtering until the amount of water and other impurities in oil up to the
qualified standard.

The principle of backward cycle filter oil circulating technique is similar to single
tank filter oil circulating technique in addition to the number of tanks of backward cycle
filter oil circulating technique one more than the latter. Connect the two tanks with filter
(name two tanks for oil tank A and oil tank B). The principle of backward cycle filter oil
circulating technique is as follows:
1. Heat and filter the oil in oil tank A by oil filter;
2. Transport the filtered oil into the oil tank B by the entrance on the top of the
tank;
3. Remove pipeline and reconnect;
4. Heat and filter the oil in oil tank B by oil filter;
5. Transport the filtered oil into the oil tank A by the entrance on the top of the
tank;
6. Repeat the step 1 to 5;
7. Keep filtering until the amount of water and other impurities in oil up to the
qualified standard.

At present, single tank filter oil circulating technique because of the low efficiency
has gradually be eliminated. If the condition allows, we often use backward cycle filter
oil circulating technique.

**The Shortcomings of Traditional Oil Filtering**

There are several problems during the process of automating the oil filtering system.

Firstly, the transformers in UHV substation are usually quite huge. Thus, the
transformer oil needs to be filtered constantly. And then because of the use of large
amount of oil, the time of filtering is usually quite long. In other words, there must be at
least one worker on the scene during filtering. It’s a waste of manpower resource.
What’s more, it’s necessary to change the pipeline connections during filtering. It’s
error-prone. We must stop the transformer when we change the pipeline. It’s inefficient
and troublesome.Finally, the low-speed filtering may be the limit of progress of works
in cross operation.
Therefore, we need to adopt new technology to realize intelligent control in UHV substation oil filtration process to improve work efficiency and achieve the automatic, fast and continuous detection of the oil.

The Development of Full Automatic Intelligent Oil Filtering System

The Design of Overall Framework

Automatic intelligent oil filtering system developed from backward cycle filter oil circulating method. By means of increasing the electromagnetic valve, the liquid flow meter, the controller and so on, the system can filter oil automatically. The principle is shown in Fig. 1. The oil filter mainly heat and filter the oil. Switching operation is controlled by the system. Sub-controller controls the opening and closing of the solenoid valve with the PLC and the control program by cumulative flow data collected by flowmeter to constitute two different pipelines and achieve the operation of inverted tank oil circulation. We use a two-position three-way solenoid valve with self-retaining function to reduce the requirements of system power supply capacity.

Algorithm Research

Automatic oil filter system through two two-position three-way solenoid valve to achieve the tank between the two tanks of the cycle of oil filter. The solenoid valve is controlled by the signal state of the liquid flowmeter located on the oil filter. Solenoid valve A and solenoid valve B constitute a differential operation, that is solenoid valve A and solenoid valve B action contrary. It can constitute different channels by opening and closing. Specific algorithm flow is as follow:

Before the start of the oil filter system, set the running time and the times of cycles. When the oil filter is started, timer and counter start working. If the initial state is poured from the oil tank A to the oil tank B. After starting the system, the cumulative flow will gradually increase by 0. When the cumulative flow reaches the preset threshold, the oil filter is completed, the solenoid valve A and solenoid valve B switch state; vice versa. The turbine flowmeter A and the turbine flowmeter B can measure the instantaneous flow in the pipeline in real time, and transmit to the control cabinet in real time. The integral operation of instantaneous flow is obtained to control the valve.
position in the automatic state. Instantaneous flow and cumulative flow will be displayed on the touch screen of the control cabinet. By means of the touch screen on the control cabinet, the total flow threshold value, the total time of filtering oil and the total number of oil filter are set up.

The detailed process of the automatic state filter is as follow: Firstly, the accumulated flow data obtained from the calculation is compared with the preset threshold in real time, and the two are not equal to do any action. When the two are equal to determine which data is provided by a flow meter, if the flow meter A, the valve will be switched from the oil tank A to the oil tank B pour oil, vice versa. After the switch is completed, the total time to determine the oil filter, if the total time has been reached, the filter will be completed after the completion of all the action; if you do not reach the preset total time, the counter +1 operation, and further determine whether the total number of times the total number of preset oil, if the value has been reached, then the oil filter is completed after the end of all actions; if the total number of preset is not reached, the real time comparison operation of the accumulated flow data and the preset threshold value is returned to the end of the oil filter.

The overall algorithm flow shown in Fig. 2.

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Figure 2. Flow diagram of algorithm.

Figure 3. Diagram of the extended application of configuration software.
**System Expansion**

On the basis of the existing system, the whole oil filtering system can be extended to the oil drainage operation of oil tank cluster. As shown in Fig. 3. An electromagnetic valve which is respectively connected with the control cabinet is arranged at the inlet and outlet of each individual tank body. Control cabinet can control the entire system of each valve according to the actual situation to choose a different way to connect the pipeline. Through the data collected by each sensor to control, to achieve automatic oil tank cluster cycle filter oil. The principle is the same as that of the two tanks, no more details.

**Benefit Analysis**

<table>
<thead>
<tr>
<th>Number</th>
<th>Comparison project</th>
<th>Traditional oil filter method</th>
<th>automatic intelligent oil filtering system</th>
<th>conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Operating efficiency</td>
<td>In different stages, it is necessary to manually operate the equipment regularly. Otherwise, the equipment can not continue the oil filtering operation. Through the manual recording of the oil filtering operation, prone to errors and omissions, etc.</td>
<td>System intelligent debugging equipment, seamless integration of various stages, the system automatically save the oil filter operation of the full range of data to facilitate the extraction of preservation, not easy to make mistakes.</td>
<td>excellent</td>
</tr>
<tr>
<td>2</td>
<td>Operating convenience</td>
<td>Workers need to operate in accordance with the progress of the oil distribution in different parts of the work area of the valve and equipment.</td>
<td>The whole system can be adjusted and the parameters can be set through the display screen.</td>
<td>excellent</td>
</tr>
<tr>
<td>3</td>
<td>Degree of automation</td>
<td>All manual operation.</td>
<td>Set the relevant parameters to start the system fully automatic operation</td>
<td>excellent</td>
</tr>
<tr>
<td>4</td>
<td>Labor cost</td>
<td>High labor costs, labor costs about 96 thousand yuan per year(3 the day staff +3 the night staff)<em>80day</em>0.2thousand yuan=96 thousand yuan</td>
<td>Labor costs are low, almost 0, can save a lot of labor costs, and can significantly reduce the artificial error caused by indirect business losses.</td>
<td>excellent</td>
</tr>
<tr>
<td>5</td>
<td>System acquisition and maintenance costs</td>
<td>Lower equipment cost</td>
<td>One-time investment costs, low follow-up costs</td>
<td>reasonable</td>
</tr>
</tbody>
</table>

Generally, the use of traditional oil filtering method as a single staff labor intensity and easy fatigue, so every time the oil filter needs at least 2-3 people to take turns on duty. This will undoubtedly increase the labor costs. And it is easy to cause the damage to the equipment when the oil is filtered by the human operator.

Through the reasonable design and selection of the system software and hardware, the automatic level control function is realized, which is convenient for the serial
communication between the system and the PC. The system is easy to operate, so it has high reliability and stability. Therefore, this system greatly reduces the labor intensity of operators, improves the degree of automation. It can bring the following benefits:

This system realizes the automatic switching of the oil tank, avoids the repeated operation of the human tank in the oil filtering process, and saves a great deal of manpower cost. The position of the oil tank is fixed in the process of the automatic pouring oil filtering, which eliminates the possibility that the pipeline switching error can be avoided, thereby avoiding the accident caused by the oil change of the main transformer in the substation, and bringing considerable enterprise benefit.

The system innovation of the traditional relay contactor control, enhances the system stability, simple operation, greatly reduces the labor intensity, improve the degree of automation system, it has good economic value and social significance, as shown in Table 1.

**Conclusion**

In this paper, the existing oil filtering methods and the existing problems are analyzed based on the requirement of the oil filtration in UHV Substation. On the basis of sensor detection technology, wireless ad hoc network communication technology, automatic control technology and so on, automatic intelligent oil filtering system effectively integrate the resources, liberate the on-site staff, realize the automatic, rapid and continuous detection of the oil, thus greatly improving the control accuracy and working efficiency in the oil filtering process. It is of great value in the engineering field, especially in the UHV project.

**References**


