

# Research of flow accelerated corrosion influencing factors on air cooling condenser

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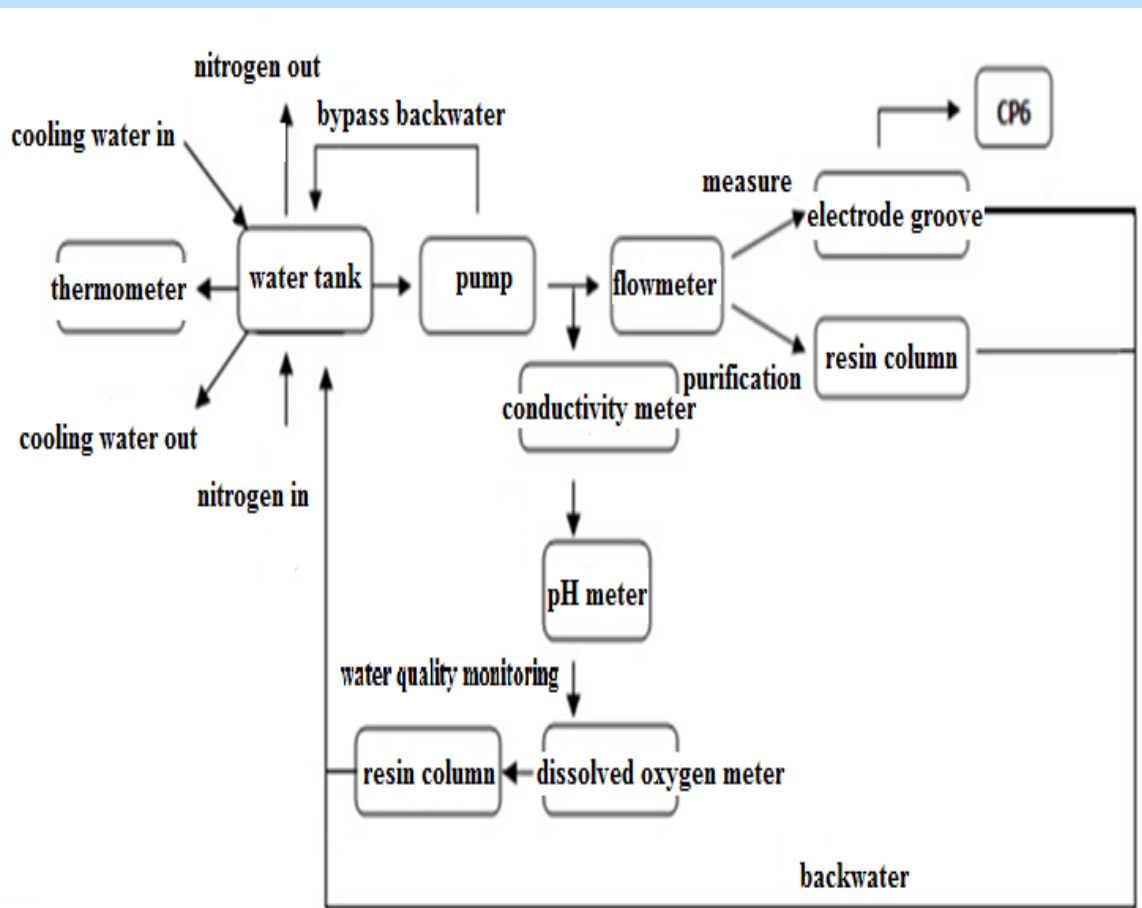
# 1 Background of The Subject

- In recent years, the construction of thermal power unit in northern China is mainly direct air-cooling unit. Direct air-cooling unit using air to cool the waste steam, it saves the water greatly. According to the statistics, using direct air-cooling unit can save more than 70% of the water than water-cooling unit.
- Direct air-cooling condenser is usually built by carbon steel, which is poor in corrosion resistance, moreover the exhaust-steam velocity is very fast, which scour the pipe surface mixed with water droplets leading to single phase and gas-liquid two phase flow accelerated corrosion(FAC).

## 2 THE Significance of This Subject

- The air cooling island FAC can lead to the increase of condensate iron content. High iron content of the condensate can cause the shorter iron removal filter operation cycle, and pollute the condensate polishing processing resin, lower the exchange capacity.
- Air cooling island FAC can lead to equipment corrosion damage, if the corrosion is severe leading to leakage, it can reduce the vacuum of air cooling island and drop thermal efficiency of the unit even shut down the unit.

# 3 Test equipment and method



Air cooling system FAC simulation experiment is conducted on self-made FAC test bed. This test bed contains the main loop of the test, water quality monitoring loop and CP6 electrochemical measurement device. The operation process of the experiment is shown in the figure

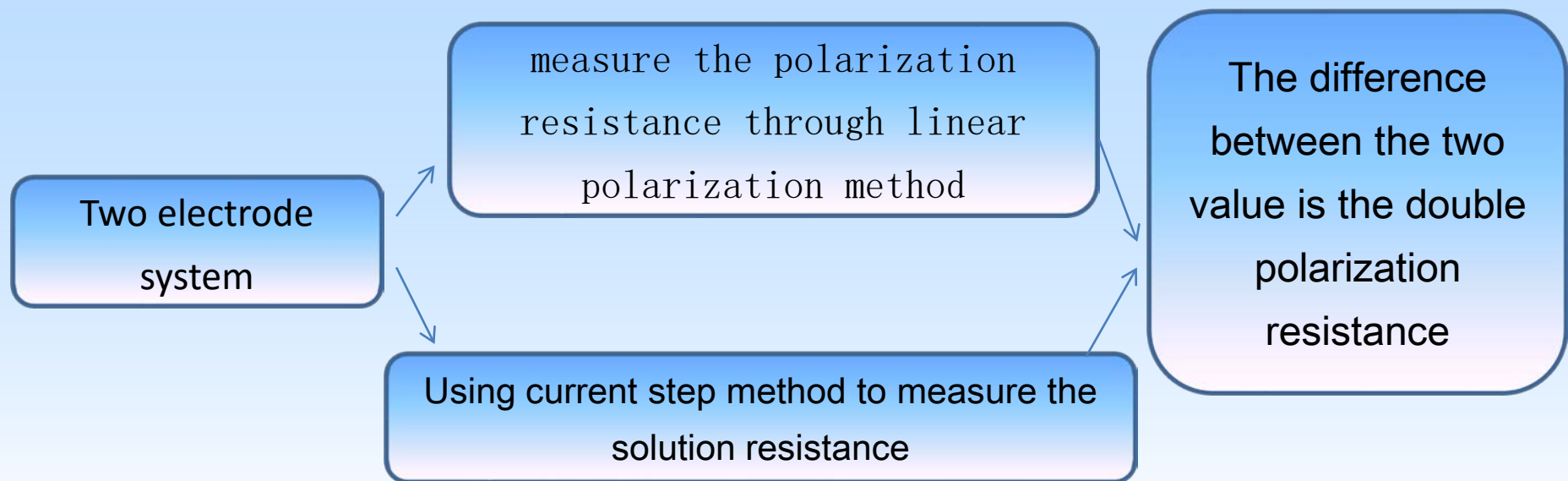
### 3 Test equipment and method

➤ Close the electrode installation road first before the beginning of the experiment, the water go through the resin column for water purification untill the conductivity is less than  $0.1 \mu\text{S}/\text{cm}$ , then closed this way, open the electrode installation road. Test running processes as shown. Adding ammonia to adjust pH value.

➤ This experiment uses the method two electrodes system which consist of two electrodes with the same area.

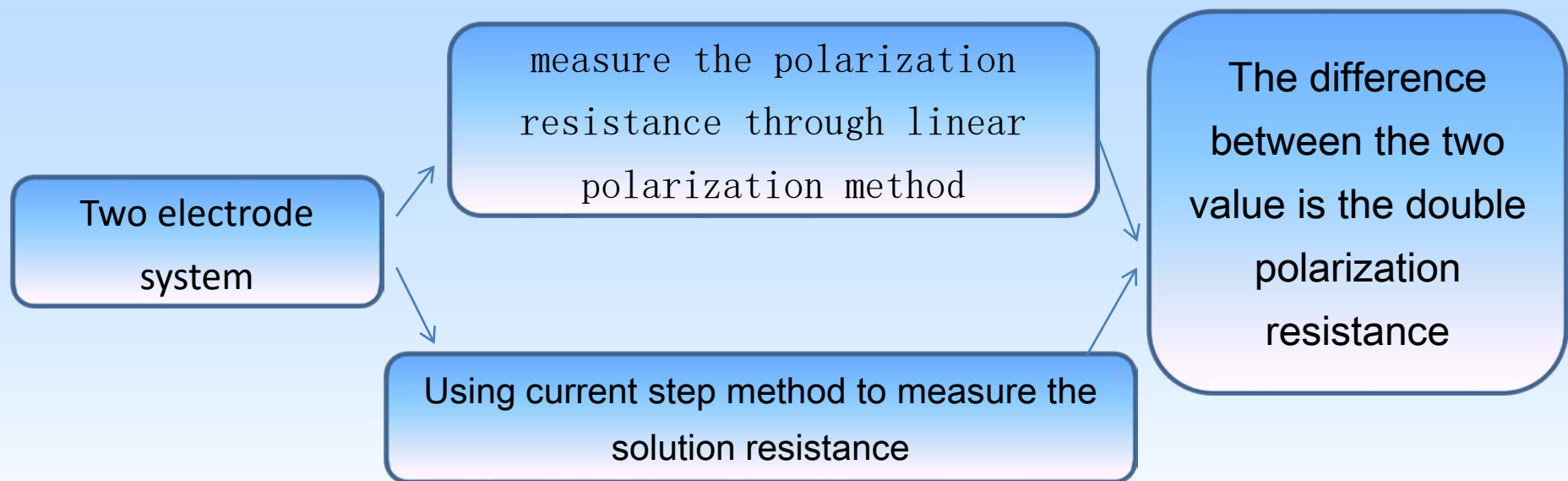
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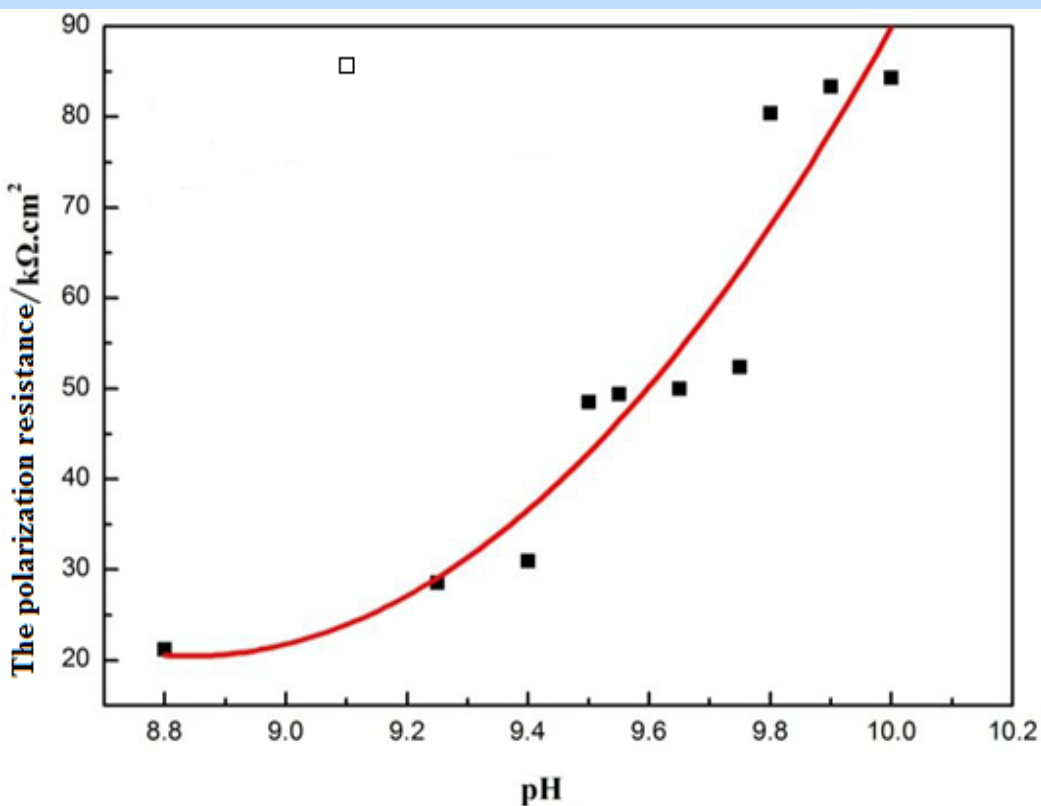
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## 4 Test results and analysis of pH value influence

### ➤ Test results and analysis of pH value influence



Adding  $NH_3$  to keep pH value, keeping the pH range change from 8.8 to 10, keeping the temperature  $50\text{ }^\circ C$ , keeping the dissolved oxygen  $100\text{ }\mu g/L$  and the flow velocity through the electrode  $6.2\text{ m/s}$ , start the experiment each time when pH is changed

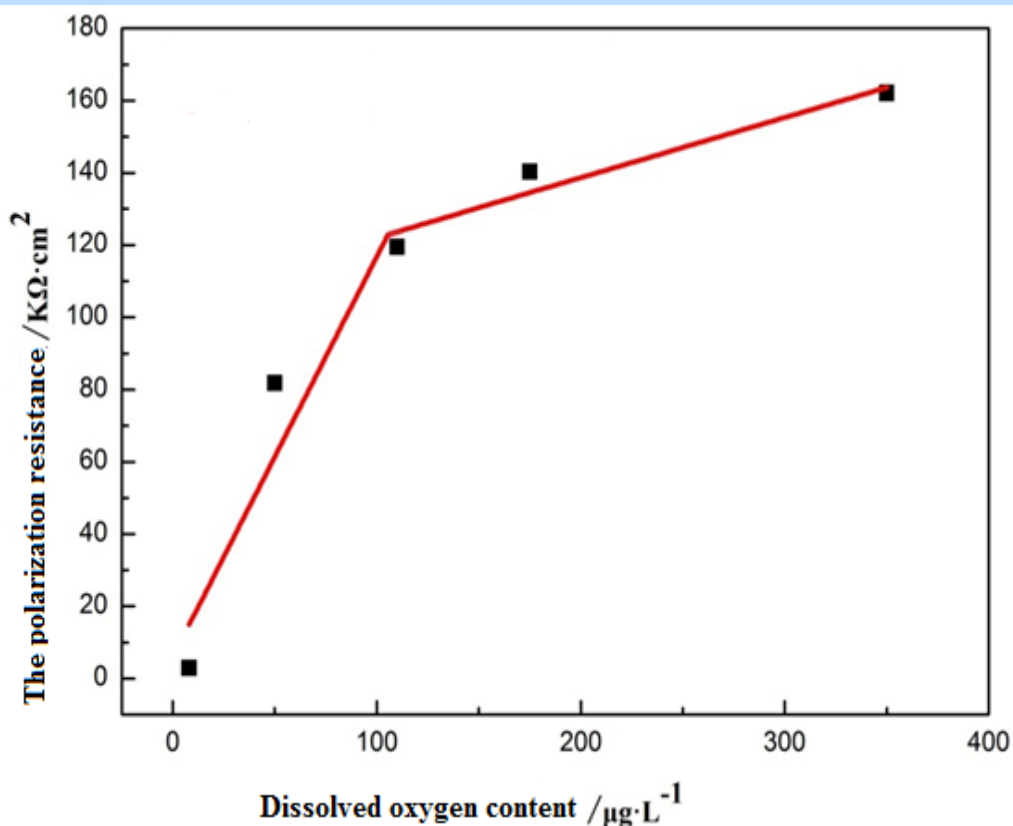
## 4 Test results and analysis of pH value influence

It can be seen from the figure that the electrode polarization resistance grows in quadratic function with the rise of pH. The higher the pH value, the slower the corrosion rate. It proved that raising the pH value can restrain the FAC.

The key to control air cooling condenser FAC is to improve the pH value of the liquid phase. TPRI has ever solve this problem through adding organic amine which has low vapor liquid distribution coefficient.

## 5 Test results and analysis of dissolved oxygen influence

### ➤ Test results and analysis of dissolved oxygen influence



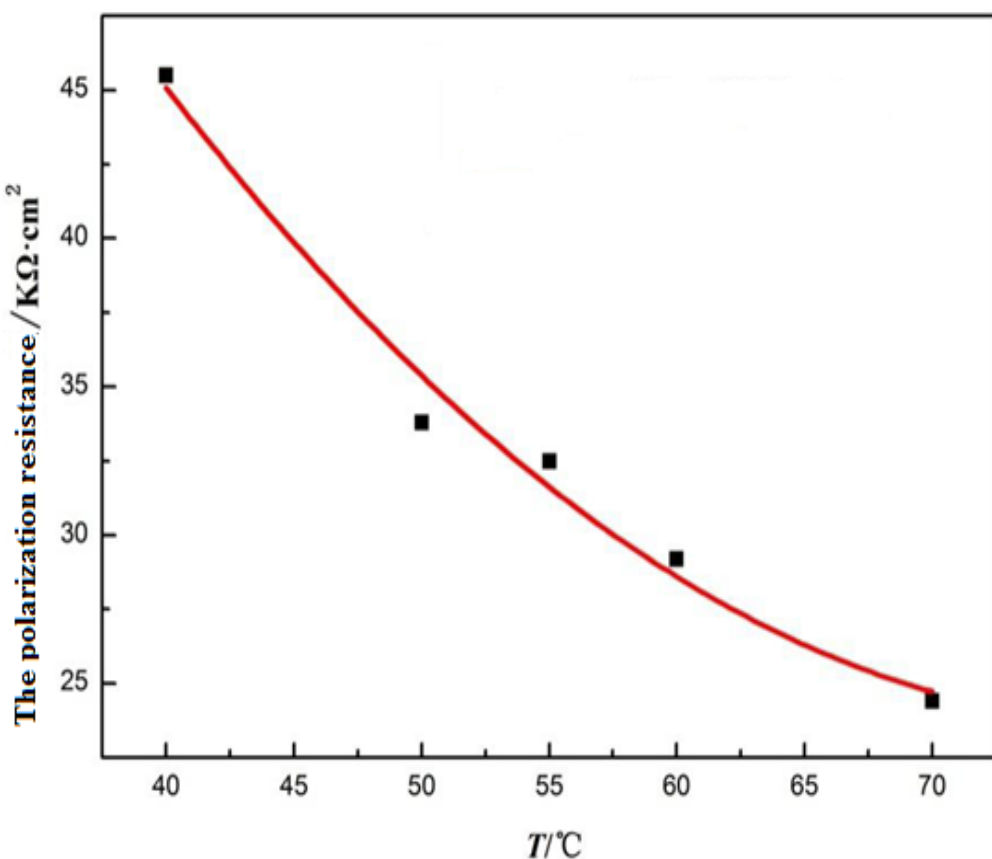
This test control the oxygen content <math><10\mu\text{g/L}</math>,

## 5 Test results and analysis of dissolved oxygen influence

As shown in figure , when the oxygen content is between 0~100 $\mu\text{g/L}$ , the polarization resistance rise accelerated with the rise of oxygen content, when the oxygen content more than 100 $\mu\text{g/L}$ , the polarization resistance rises lower with the rise of oxygen content.

## 6 Test results and analysis of temperature influence

### ➤ Test results and analysis of temperature influence



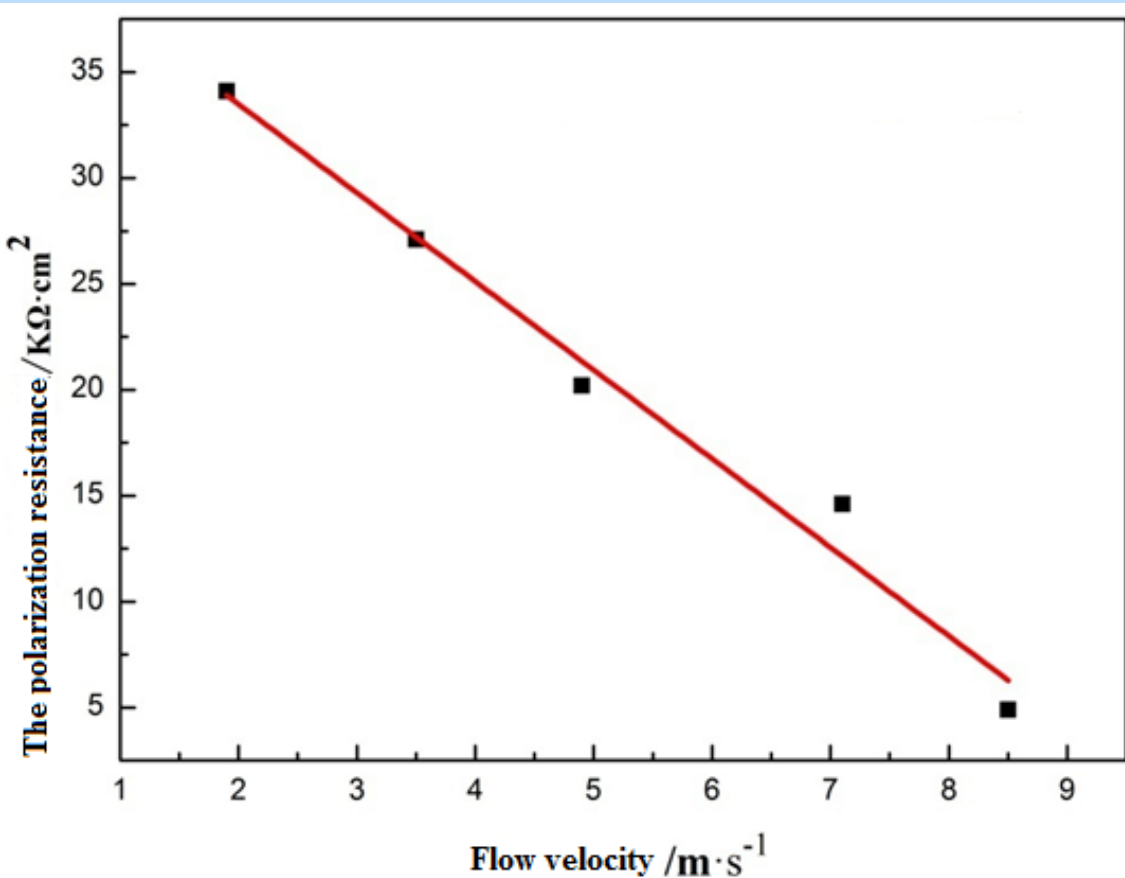
For the air cooling unit, the highest condensation temperature reached over 70°C in summer, and lowest drops to 40°C in winter. Under the experimental conditions, temperature is 40°C, 50°C, 55°C, 60°C and 70°C, respectively; pH is around 9.4; dissolved oxygen level is around 150μg/L; drainage line velocity is 8.5m/s.

## 5 Test results and analysis of dissolved oxygen influence

Temperature is an important factor which affects FAC of carbon steel, low-alloy steel. The higher the temperature is, the faster the speed rate of corrosion of high-carbon steel grows, the lower pH of water phase and vapor phase is. At low temperatures ( $T < 150\text{ }^{\circ}\text{C}$ ) the corrosion reaction speed is the limit factor, therefore, the higher the temperature the faster the corrosion reaction. When the temperature continues to rise the speed is controlled by corrosion products diffusion speed, it will reduce gradually.

## 7 Test results and analysis of velocity influence

### ➤ Test results and analysis of velocity influence



Under the experimental conditions, temperature is  $50^{\circ}\text{C}$ ; pH is 9.5; dissolved oxygen level is  $20\mu\text{g/L}$ ; drainage line velocity range from  $1.9\text{m/s}$  to  $8.5\text{m/s}$ .

## 7 Test results and analysis of velocity influence

The mass transfer rate that corrosion products( $\text{Fe}^{2+}$ ) flow to the bulk solution accelerates the increasing of flow velocity. Moreover, shear is generated by high speed liquid flows flushing pipe. The resulting shear force makes the oxide films of the condenser surface thinner. So the velocity of FAC accelerates with the increasing of resistance of mass transfer. The study shows that the flow accelerates corrosion(FAC) to equipments mainly takes place at where local velocity is higher and occurs turbulence. The levels of the element Cr in carbon steel also suppresses increasing of the FAC velocity. What is more, low alloy steel have great higher corrosion resistance than carbon steel. One percentage mass fraction of element Chromium also can make the FAC velocity lower or even a negligible effect. So low alloy materials will be suit for the design where occurred FAC easily.



## 8 Conclusion and prospect

- Improving initial condensate pH value can effectively restrain the speed of the FAC, Without affecting the condensate polishing treatment capacity adding organic amine which has low vapor liquid distribution coefficient can be considered.
- Studies have shown that increase the dissolved oxygen content to more than 100  $\mu\text{g/L}$  can effectively restrain the FAC, In the operation adding oxygen affects the vacuum of the condenser and is unfavorable to judge the condenser leakage according to the oxygen content, whether we can improve the dissolved oxygen content through adding appropriate hydrogen peroxide needs to be further research.

## 8 Conclusion and prospect

- The FAC velocity of air-cooling condenser will raise according to the raise of temperature, Therefore during summer runtime monitoring of air cooling condenser back pressure and temperature of the condensate is necessary, and then spraying water or regulating fan speed to reduce temperature In time.
- The FAC speed corresponds to the flow velocity, FAC usually occurs in areas of turbulence, velocity cannot be controlled artificially, so we may consider using low alloy steel to Inhibit FAC in area that has disturbance such as variable diameter or bend place.

Thanks !