RESEARCH ON THE HUMIDITY ABSORPTION OF SOME ELECTRODE COATINGS FOR ARC WELDING

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The electrode coating is the most important source of moisture contained in hydrogen for electric arc welding and coated electrodes. Considering that this issue is taken into account in research in the field of metallurgy and melt welding technology, as well as in the field of elaboration of coated electrodes for welding.

The presence of moisture in the coating of electrodes leads to the formation of hydrogen during welding, which is the main factor influencing the cold cracking of welded structures.

This paper proposes an analysis of the humidity sources of welding electrode coatings, the influence of relative humidity and air humidity content of some types of electrodes coatings for arc welding.

Keywords: electric arc, electrode coating, relative humidity, diffusible hydrogen.

1. Humidity sources of the electrodes coating

The different forms of water existence in the electrodes coating for electric arc welding are classified into three groups: absorbed, crystallization and chemically bonded. Each of these groups characterizes the bonding energy with the solids that make up the electrode coating and therefore the conditions in which water can be removed from the coating when the electrodes are dried both in the manufacturing process and before being used for welding.

Absorption water is considered not only the total of water molecules related to solids by the absorption energy but also that obtained by the capillary effect of the porosities of the electrode coating. That's why this group is called water retained by hydroscopy.

This water has relatively low energy binding to solid body surfaces, and during drying it is that traction of moisture that leaves the first the coating of the electrodes. This is done at temperatures below 200 ° C according to the drying diagram depending on the thickness of the electrode coating and its composition.

Thus, a finishing drying temperature of 130 ° C is used at Supertit electrodes, resulting in a humidity of 0.3%. For cellulosic and rutile electrodes the

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drying temperature is lower in order not to destroy some components in the coating.

Complying with drying patterns on different types of electrodes is an important part of preventing the cracks in the coating.

Crystallization water is part of the crystal structure of a whole series of chemical combinations. Since its removal from the crystal is possible only by destroying or re-establishing its structure, its binding energy is greater than one of the absorption water. The crystallization water can only be removed at temperatures of 400-500^0 C.

Chemically bonded water is not only a structural component, it is part of the chemical compound molecule. The binding energy is so high that it leaves the electrodes coating at high temperatures of 1200^0 C.

The distinction between crystallization water and chemical bonding water consists in the fact that the first one does not modify the binding force between the chemical combinations' ions, while the second modifies the chemical bonds between the various atoms and the chemical properties of the binder.

Fig. 1 gives, based on statistical data, the moisture content permissible for some types of coated electrodes.

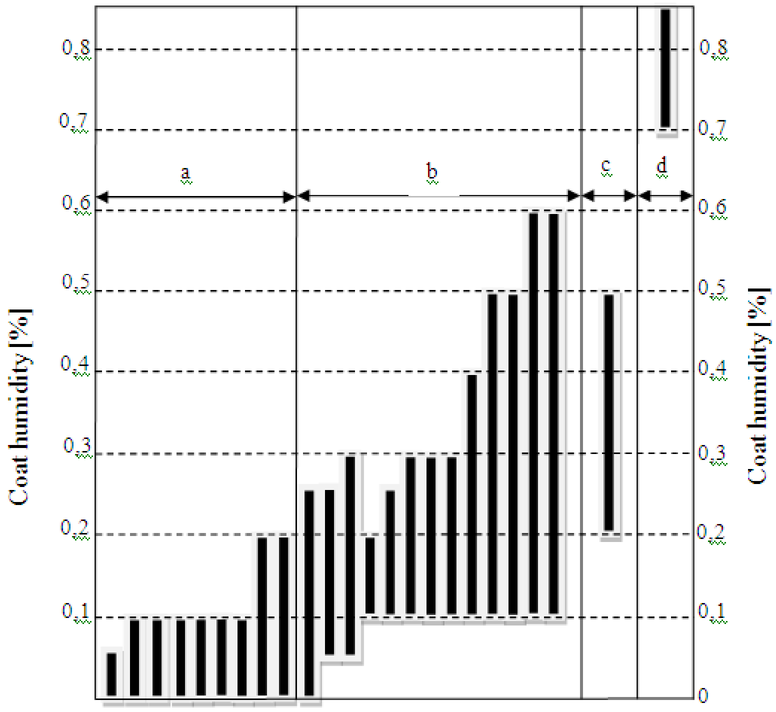

Fig. 1. Allowed humidity content for some types of coated electrodes: a- basic, b- rutile, c- acid, d-cellulosic

Analyzing the data in Fig. 1, the following conclusions can be draw:

- For basic electrodes, the maximum moisture content limit is 0.2% and for some assortments of 0.05 or 0.1%;
- maximum limit for rutile electrodes is 0.6%;
- For cellulosic electrodes this limit may reach 1.5%.

Of course, the residual humidity from drying must be less to be in the safety range until welding, since from the time of drying to the time of use, the coating will receive some moisture from the environment.

2. Factors that influence the kinetics of humidifying the electrodes coatings

A climate in which the state of the atmosphere is maintained within the tolerance range is generally defined by four sizes. These magnitudes, which are called factors of influence of the kinetics of humidifying the electrodes are:

- relative air humidity;
- air temperature;
- atmospheric pressure;
- air flow speed.

Taking into account the fact that it is generally welded in enclosed spaces, the influence of atmospheric pressure and the speed of air flow is virtually negligible.

The tests carried out have shown that the humidity content of the electrode coating changes according to any change in relative air temperature and humidity. This is primarily altered by the fact that the relative air temperature and humidity give the water content and the partial pressure of the water vapor, and secondly that the capillaries ending on the outside of the surface of the water level are permanently aligned to outside conditions. Fig. 2 shows the relationship between relative humidity and air temperature.

It is noted that for a content of 13 g water/m^3 air for 100% relative humidity and 15 ° C, 30 ° C corresponds to a humidity of 45%.

So, in the first case, electrodes that are free in the atmosphere can no longer be used after a certain amount of time, and if the temperature rises to 30^0 C, they may be stored for a long time before use.

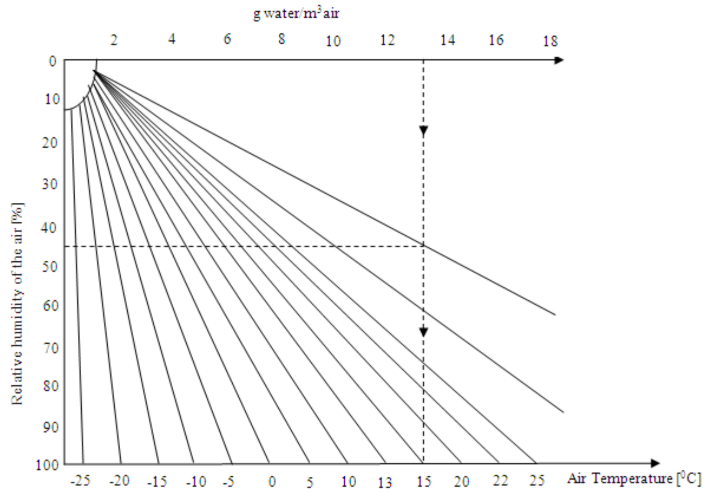

Fig. 2 Variation of water content in air at various relative air temperatures and humidity

Fig. 3 shows a diagram for determining the partial pressure of water vapor for various relative air temperatures and humidity.

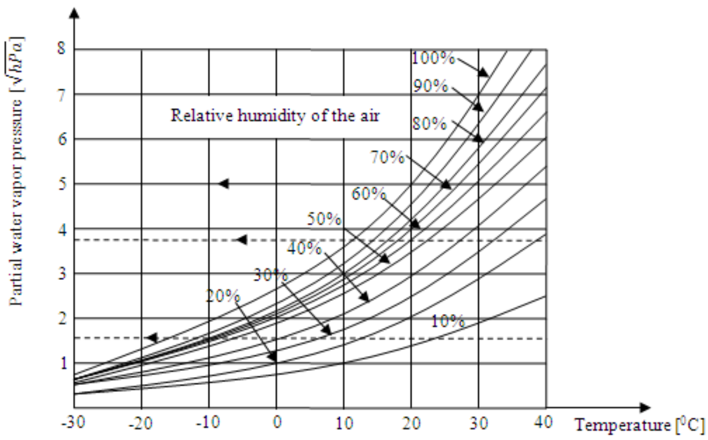

Fig. 3 Diagram for determining the partial pressure of water vapor

3. Experimental results

Equipment used for experimental research was:

- VTRK - 500 climate chamber, which allows the temperature and relative humidity of the air to vary;
- an oven for drying electrodes before humidification;
- devices for determining the initial humidity of the electrodes coating by the thermogravimetric method;

- electronic digital balance for weighing electrodes after a certain amount of time when the electrodes have been humidified.

The humidification conditions as well as the materials used were the:

- two types of electrodes: with basic coating and rutile;
- the diameter of the electrodes: 4,0 mm;
- humidification temperature: 30^0 C;
- relative humidity of the air: 50%, 70% and 90%;
- drying temperature of the electrodes before humidification: 300^0 C;
- drying time: 2,5 hours;
- electrodes number for each coating type: 2.

The experimental results are presented in Table 1, with the specification that the table only comprises the humidity determined as an average of the two electrodes used for each coating type.

Table 1

Electrode type	Relative humidity of the air [%]	Initial humidity before humidification [%]	Coating humidity after [%]						
			0,5h	1h	2h	3h	4h	6h	8h
Basic	50	0,18	0,68	1,28	1,96	2,24	2,36	2,66	2,72
	70	0,20	1,24	2,14	2,66	3,58	3,68	3,84	3,92
	90	0,16	1,66	2,42	3,20	3,68	3,86	4,00	4,14
Rutile	50	0,34	1,12	2,42	3,38	3,96	4,02	4,14	4,24
	70	0,38	2,14	3,22	4,12	4,84	4,96	5,02	5,08
	90	0,35	2,82	3,94	4,86	5,74	6,12	6,34	6,42

4. Interim Conclusions

Analyzing the experimental results, we can draw the following conclusions:

a. In terms of moisture absorption, basic and rutile coatings have a identical behavior. The rutile type absorbs more humidity compared to the basic one. The base type absorbs humidity more slowly and in smaller quantities, but its coating tends to bind chemical water and retain it. For example, at a relative humidity of 70% and a holding time of 2 hours, the humidity of the rutile coating is 60% higher than that of the base coating (Figs. 4 and 5).

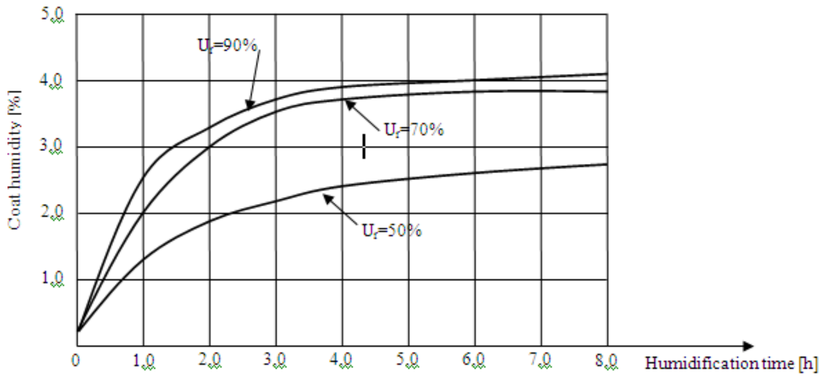

Fig. 4 Humidity variation of the base coating for different relative humidity U_r

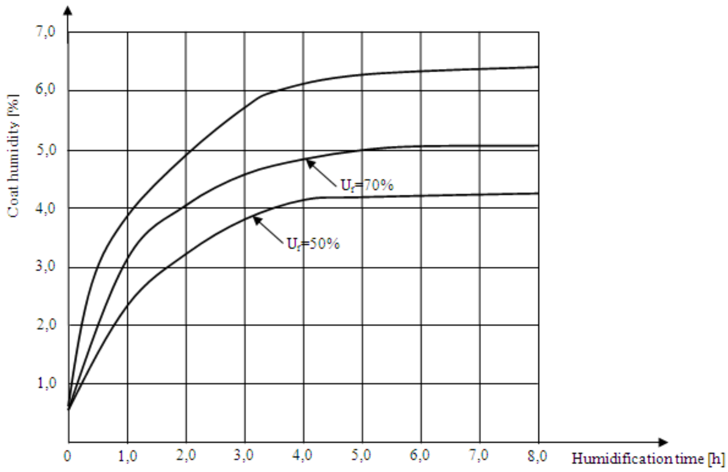

Fig. 5 Humidity variation of the rutile coating for different relative humidity of the U_r

5. Final Conclusions

b. The electrodes' absorption by the electrodes coating is nonlinear for the first 4 hours, and then linear, remaining practically constant, for a relative constant humidity of the air. The first period of time is critical; it can be seen the first 4 hours after removing the electrodes from the box and storing it outdoors. During this time the moisture absorption is very fast, then the curve passes almost horizontally, and the cover reaches the saturation point.

c. For each relative humidity in the atmosphere there is a certain degree of saturation, which is even higher as the relative humidity is higher. This means that if the humidity in the atmosphere increases at the same temperature, or if the temperature drops to the same humidity, when the relative humidity increases, there is a higher reception curve and a higher saturation point. Due to these causes the humidity of the electrode shell increases.

d. Each type of electrodes indicates another curve path at the same relative humidity, that is a different saturation value. It is therefore necessary to determine for each type of electrodes both the sensitivity and the resistance to humidity.

e. Knowing the influence of relative air humidity on the moisture content of the electrodes coating is very important as measures can be taken on packing, storing and firing the coated electrodes before use in the welding process.

R E F E R E N C E S

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