EXPERIMENTAL RESULTS ON SYNTHETIC COOLING ENVIRONMENT

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Abstract: *A synthetic cooling environment is proposed and analyzed for metallic materials heat treatments. Cooling as final operations of thermal treatments represent a special importance because she determines the structure and implicitly the properties of thermal treated samples. For a correct chose of a cooling environment must be analyze the kinetic cooling curve of alloy (T.R.C. diagram) and it compares to environments cooling curves. The paper is presenting a way to change carboximetil cellulose adding Na2CO3 5% by changing the agitation state of the environment. There were studied compared the cooling oil such as TT50, CMC solution 1% in water + 5% Na2CO3 with and without agitation, there were drawn cooling curves of a standardized Ag tube in the above environments, with and without agitation.*

Keywords: *cooling, oil TT 50, carbo-dimetil cellulose.*

1. Introduction

Cooling represent a final operation of thermal treatments having a special importance based on the determination of the structure and implicitly the properties of thermal treated samples.

For a correct chose of a cooling environment must be analyze the kinetic cooling curves of the alloy (T.R.C. diagram) and compare to environments cooling curves. The normal conduit of the cooling process has an important role for operation success with purpose of obtaining some structures in sample section (martensitic water quenching type structures) without producing quenching defects as cracks, deformations or big remanent tensions.

An usual cooling environment is industrial oil but the oil have the disadvantage of a high ignition danger, is a non-ecological environment (because of gas emanations which appears during hardening), for this was searched replacement of mineral oil for thermal treatment there was possible with cooling alternatives with reduce or non-start ignition danger which can be synthetic environments.

Carboxymethyl cellulose (CMC) is a synthetic environment, it meets ecological criteria much better than oil heat treatment (the danger of ignition is eliminated) and is much cheaper because it is a byproduct of the paper factories. The inconveniet is only that there are not the same performance such as cooling in oil heat treatment but presence also advantages in controling the cooling stage. Another very important factor is represented by the environment agitation degree which modifies substantially the cooling curve, implicit instantaneous cooling rates and thermal transfer on different periods.

2. Methodology

The paper will present a way to change carboximetil cellulose adding Na2CO3 5% by changing the agitation state of the environment.

There were studied compared the cooling oil such as TT50, CMC solution 1% in water + 5% Na2CO3 with and without agitation, there were drawn cooling curves of a standardized

Ag tubes in the above environments, with and without agitation.

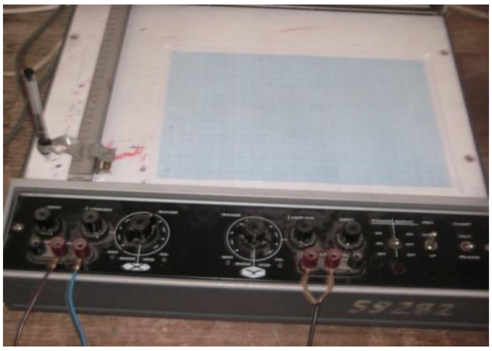
Based on cooling curves were calculated and drawn curves for temperature variation speed of the cooling process and for the coefficient variation of thermal transfer tube-environment.

Was calculated in each case and cooling intensity.

Were drawn following curves for the cooling media hardening: Oil TT50, Carboximetil cellulose solution 1% in water+5%NaCo3 and Carboximetil cellulose solution 1% in water+5%NaCo3 agitated (v=100mm/s)

To make a comparison between the cooling media of the above mentioned, all were heated to 40 ˚ C.

Figure 1. *Image of the equipment for determination of the characteristics of cooling stage*



a)

b)

c)

Figure 2 *Equipment used in investigation: a) Recorder y-t, b) base time, c)silver samples with the following sizes and features:Ø = 12,5 [mm] , h= 25 [mm], S = 1408 [mm^2], m= 39.9 [g], ρ_{Ag} = 10.5 g/cm^3 λ_{Ag} = 418.5 W/m·*

Facility as a whole is shown in the picture above and consists of the following main elements: Silver test tube, Cooling precinct, Furnance, Electric power supply, Cromel – Alumel thermocouple, Milivoltmeter for indication, Recorder OH 816/H.

Test tube was heated in the oven to 800°C temperature then was introduced into this researched environment, the cooling curve was recorded on ‚yt recorder'.

For each of the cooling medium were calculated: cooling rate on intervals [ºC/s], thermal transfer ceficient on intervals.

$$\alpha_i = \frac{3600 \cdot m \cdot c}{\Delta t_i \cdot S} \ln \frac{T_i - T_o}{T_f - T_o} \quad [w/m^2k]$$

where:

m = 0.0399 [kg] sample mass;

c = 0.056 [kcal/kg·grd] specific heat of silver;

S = 0.001408 [m^2] sample surface;

Δt [s] time interval;

T_i T_f [ºC] final and initial temperature on interval.

T_o environment temperature.

3. Results and discussion

The obtained results were put in a table and based on them were made:

- Cooling curves T = f (t) (table 1)

***Table 1**: Characteristics of cooling curves in different cooling environments*

Temperatur e	Oil TT 50	CMC 1% +Na_2CO_3 agitated	CMC 1% +Na_2CO_3
800	0	0	0
780	1,8	3,5	3,5
760	4	5	8,7
740	7	7	10,5
720	8,6	8,6	13,5

700	13	13	16
680	15,5	16	21,5
660	17,8	19,5	25,5
640	19,5	23	30
620	21	25,7	34,7
600	22,5	29,1	39,5
580	23,5	31,8	44,5
560	24,5	34,5	49,5
540	25,7	37,7	54,5
520	26,5	40,5	60
500	28	43	64
480	29,3	45,7	69
460	30,5	48,5	73,5
440	32	51	77,5
420	33,8	52,2	82
400	35,5	53,5	85
380	38	55	88
360	41	56	89,7
340	44	57	91,4
320	48,5	58	92,4
300	53,5	58,5	93,3
280	60,5	59,3	94
260	70	61	94,7
240	83	63	96
220	101	65	98,5
200	127	67,5	103
180	156	69	108
160	200	71	113,7
140	245	74	120
120		78,5	128
100		85	150
80		100	200
60		240	290
40			
20			

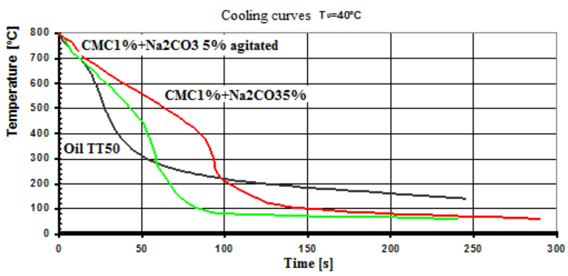


Figure 3 *Cooling curves of temperature-time for different cooling environments*

- Cooling rate variation depending on temperature $v_r = f(T)$

Table 2: Cooling speed variation depending on the temperature $v_r = f(T)$

Temperature	Oil TT 50	CMC 1% +Na2CO3 5% agitated	CMC 1% +Na2CO3 5%
800	0	0	0
700	8,00	6,67	3,64
600	20,00	7,41	4,00
500	15,38	7,41	4,00
400	8,00	13,33	6,67
300	2,86	25,00	28,57
200	0,69	13,33	4,00
100		3,08	0,91
80		1,33	0,40
60		0,14	0,22

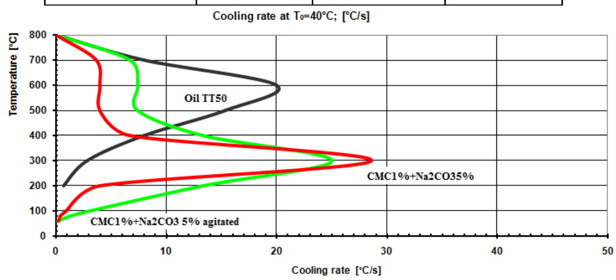


Figure 4 *Chart for cooling speed variation depending on the temperature*

- Coefficient of heat transfer variation depending on the temperature $\alpha_i=(T)$.

Table 3 Coefficient of heat transfer variation depending on the temperature $\alpha_i= f(T)$

Temperature	Oil TT 50	CMC 1% +Na2CO3 5% agitated	CMC 1% +Na2CO3 5%
800	0	0	0
700	37,64	37,64	66,24
600	129,12	56,96	40,35
500	155,48	93,29	58,30
400	172,37	225,41	97,68
300	78,83	788,31	437,95
200	23,15	240,77	133,76
100		196,12	57,95
80		109,57	32,87
60		16,55	25,74

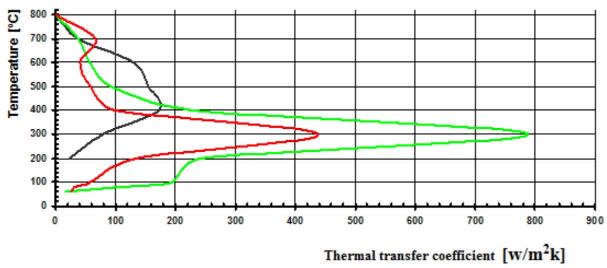


Figure 5 *Coefficient of heat transfer variation depending on the temperature*

Based on cooling curves were calculated and drawn curves for temperature variation speed of the cooling process and for the coefficient variation of thermal transfer tube-environment.

The cooling rates at different synthetic percentages were determined in order to be compared with the effects of oil heat treatment baths. The aspects of ecological effect of these new oil-alternatives are very important in metallurgical field increasing the value of synthetic mediums for cooling.

3. Conclusions

Solutions C.M.C. 1% in water with 5% addition of Na_2CO_3 are some environments that have adequate hardening certain advantages both environmentally friendly and cost price and can replace oil in certain conditions of heat treatment.

A definitely quality improvement cooling for hardening of the environment studied is observed when agitated environment.

The normal conduit of the cooling process has an important role for operation success with purpose of obtaining some structures in sample section (martensitic water quenching type structures) without producing quenching defects as cracks, deformations or big remanent tensions.

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