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RESEARCHES REGARDING TEMPERATURE INFLUENCE ON CLASSIC AND SYNTHETIC QUENCHING MEDIUM

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ABSTRACT

In this paper were analyzed experimental graphics for quenching cooling curves of oil at 20°C,40°C,60°C, 80°C and carboxymethyl cellulose (CMC) 1,5% solution in water at the same temperatures. Velocity cooling was studied on intervals, all studied within the first 10 cooling seconds.

KEYWORDS: heat transfer coefficient, polyachilenglycol, cooling medium, cooling curves, cooling intensity

1. Introduction

The normal conduit of the cooling process plays an important role in the operation success; its purpose is to obtain some structures in sample section (martensitic water quenching type structures) without producing quenching defects such as cracks, deformations or big remnant tensions.

For a correct choice of a cooling medium must be analyzed the kinetic cooling curve of alloy (T.R.C. diagram) and it must be compared to environments cooling curves. The main feature of a quenching medium is its cooling capacity defined as the ability to take heat from the hot part. Generally, industrial cooling medium provide continuous variable cooling speed.

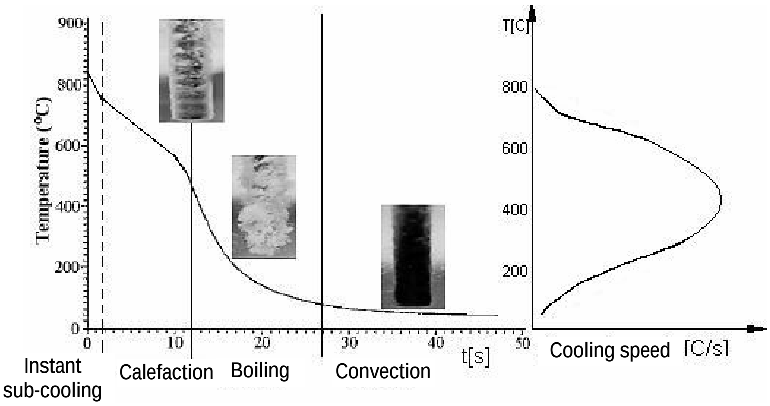

***Fig. 1**. Cooling main stages schematic representation*
a) Cooling curve b) the rate of cooling

Medium cooling capacity is determined by the heat transmission coefficient from the part surface to the medium, transmission that is carried by radiation, convention and conduction.

I) Instant sub-cooling, result of high energy consumption for sudden vaporization of hardening medium;

II) Calefaction - represents the forming of a vapour film adhering to the part surface where heat is transmitted by radiation

III) Boiling bubble

IV) Convection occurs below the boiling temperature of quenching medium.

Cooling capacity of quenching media is influenced by:

• Agitation degree for the quenching medium.
• Medium temperature
• Surface condition parts
• Degree of contamination with soluble or insoluble substances

At the beginning of hardening, during boiling film, cooling is relatively slow.

If this period is extended too far, it is not possible to avoid premature austenitic transformation, which can yield a small or uneven hardness.

At this stage of the cooling process the temperature of the used liquid plays a major role. It was found that for water and aqueous solutions, the period of this phase increases with the cooling temperature.

For conventional quenching oils, boiling film phase is longer. Higher boiling oils point makes the temperature and not to influence the period of this phase or makes them usable when hot, without the risk of incomplete quenching. This is an advantage because the quenching power of hot oil, in effervescent boiling period, is bigger than the cold oil.

The reason is that hot oil viscosity decreases and allows a better circulation of the liquid during bubble boiling, hurrying vapour removal from the surface pieces and favouring a better connection to them.

2. Experimental results

The work was done plotting cooling curves of test-pieces in two cooling mediums: heat treatment oil TT50, carboxymethyl cellulose 1.5% solution in water. In order to achieve the experiment the quenching environments were heated in calorimeter at 80^{0}C, 60^{0}C, 40^{0}C, 20^{0}C.

The experiment was performed using the installation from Figure 2.

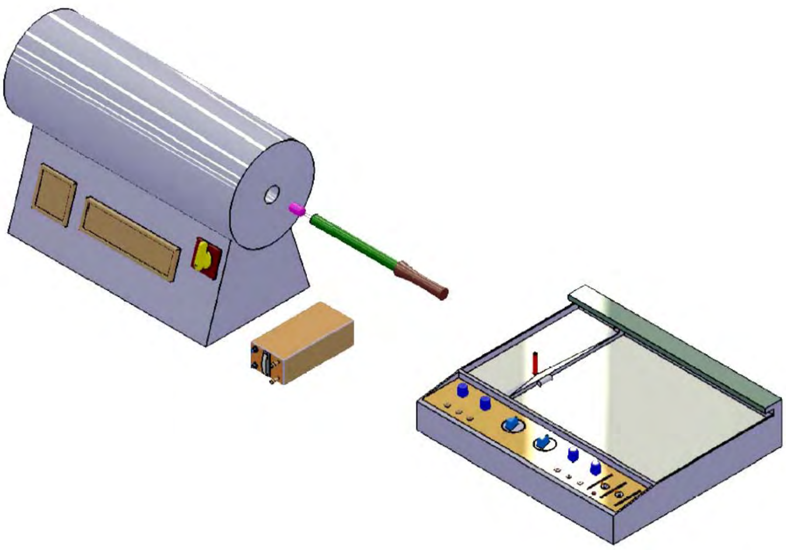

***Fig. 2**. Installation for the determination of cooling characteristics.*

***Fig. 3**. 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·

The installation consists of: silver test piece, cooling precinct, electric power supply, Cromel – Alumel thermocouple, milivoltmeter for indication, recorder OH 816/H

Test piece was heated in the oven to 800°C temperature afterwards it was introduced into researched medium, the cooling curve was recorded on,"y-t recorder".

For each of the cooling media were calculated:

- Cooling rate on intervals [^{o}C/s]
- Thermal transfer coefficient on intervals.

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

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 [^{o}C] final and initial temperature on interval.

T_o medium temperature.

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

- Cooling curves T = f (t) (table 1)
- Cooling rate variation depending on temperature v_r = f(T)
- Heat transfer coefficient variation depending on the temperature α_i=f(T).

Table 1. *Cooling curve for heat treatment of TT 50 oil at different temperatures [s]*

Temperature[°C]	Oil TT 50 T_0=20°C	Oil TT 50 T_0=40°C	Oil TT 50 T_0=60°C	Oil TT 50 T_0=80°C
800	0	0	0	0
700	1.28	0.88	1.04	1.04
600	2	1.4	1.64	1.56
500	2.44	1.76	2	1.88
400	3	2.2	2.4	2.32
300	4.2	3.32	3.32	3.32
200	9	7.32	7.52	7.52
180	10.8	10	9.4	9.4

Table 2. *Cooling speeds for TT50 Oil at different temperatures [°C/s]*

Temperature [°C]	Oil TT 50 T_0=20°C	Oil TT 50 T_0=40°C	Oil TT 50 T_0=60°C	Oil TT 50 T_0=80°C
800	0	0	0	0
700	100.00	125.00	166.67	166.67
600	166.67	250.00	166.67	250.00
500	250.00	250.00	250.00	500.00
400	166.67	166.67	166.67	166.67
300	55.56	62.50	83.33	83.33
200	12.50	25.00	13.16	13.16

Table 3. *Heat transfer coefficient for TT50 Oil at different temperatures [W/m²k]*

Temperature [°C]	Oil TT 50 T_0=20°C	Oil TT 50 T_0=40°C	Oil TT 50 T_0=60°C	Oil TT 50 T_0=80°C
800	0	0	0	0
700	828.02	1035.03	1380.04	1380.04
600	1613.98	2420.98	1613.98	2420.98
500	2915.18	2915.18	2915.18	5830.35
400	2441.97	2441.97	2441.97	2441.97
300	1094.87	1231.73	1642.30	1642.30
200	376.20	752.40	396.00	396.00
180	373.83	251.08	357.92	357.92

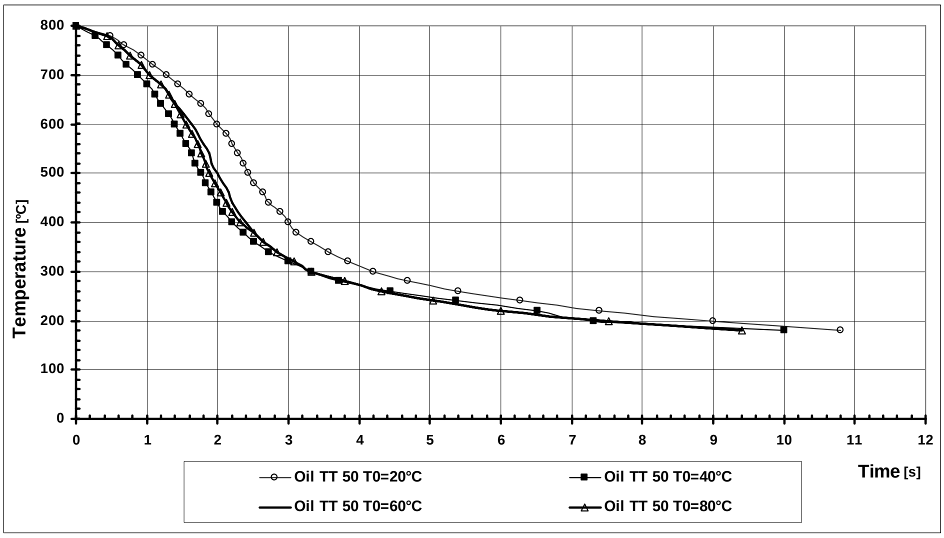

Fig. 4. *Cooling curves at different temperatures for TT 50 Oil*

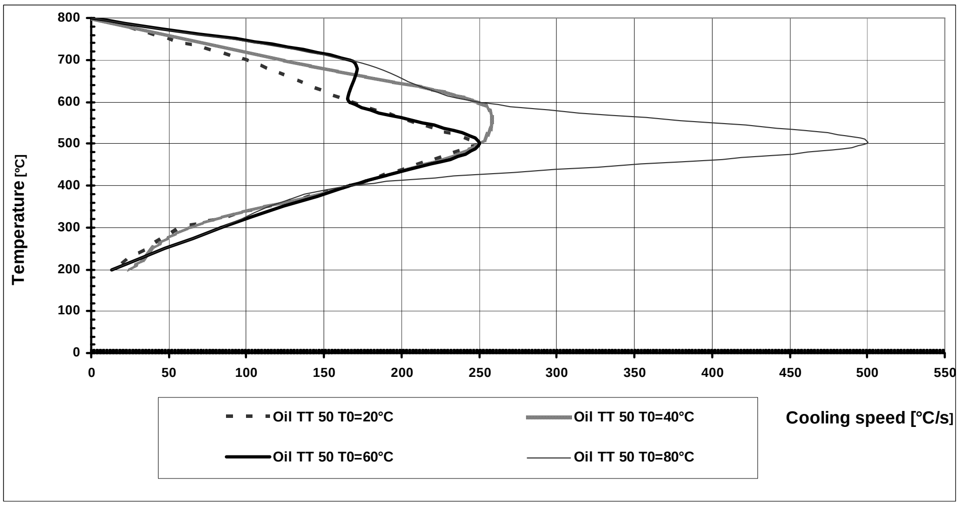

Fig. 5. *Cooling speed variation for TT50 Oil at different temperatures*

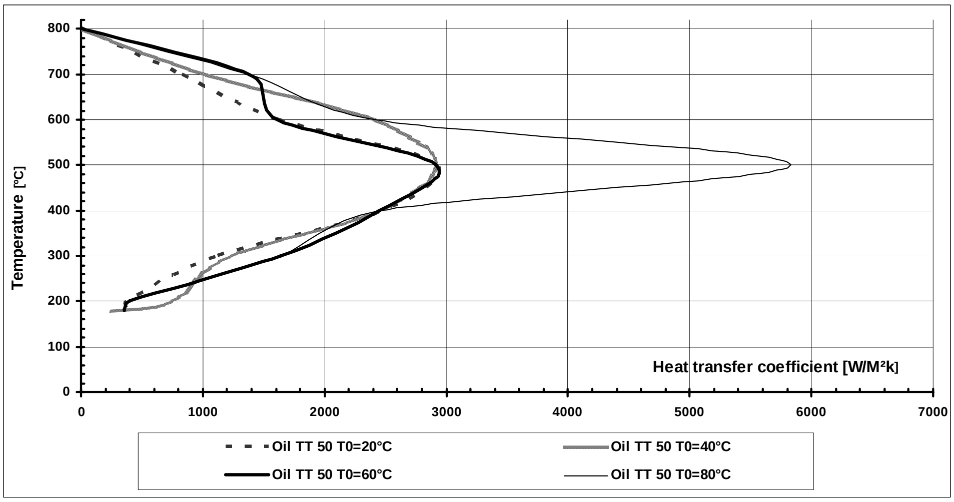

Fig. 6. *Heat transfer coefficient variation for TT 50 Oil*

Table 4. *Cooling curves for CMC 1.5% at different temperatures [s]*

Temperature[°C]	CMC 1.5% T_0=20°C	CMC 1.5% T_0=40°C	CMC 1.5% T_0=60°C	CMC 1.5% T_0=80°C
800	0	0	0	0
700	2.08	2.28	2.72	2.88
600	4.08	4.24	4.92	5.80
500	6.84	7.20	7.92	9.12
400	9.84	10.40		
380	10.60	11.60		

Table 5. *Cooling speeds for CMC 1.5 % at different temperatures [°C/s]*

Temperature[°C]	CMC 1.5% T_0=20°C	CMC 1.5% T_0=40°C	CMC 1.5% T_0=60°C	CMC 1.5% T_0=80°C
800	0	0	0	0
700	55.56	71.43	41.67	50.00
600	38.46	38.46	45.45	40.00
500	35.71	35.71	41.67	29.41
400	33.33	33.33		
380	26.32	16.67		

Table 6. *Heat transfer coefficient for CMC 1.5% at different temperatures [W/m²k]*

Temperature[°C]	CMC 1.5% T_0=20°C	CMC 1.5% T_0=40°C	CMC 1.5% T_0=60°C	CMC 1.5% T_0=80°C
800	0	0	0	0
700	460.01	591.44	345.01	414.01
600	372.46	372.46	440.18	387.36
500	416.45	416.45	485.86	342.96
400	488.39	488.39		
380	406.43	257.40		

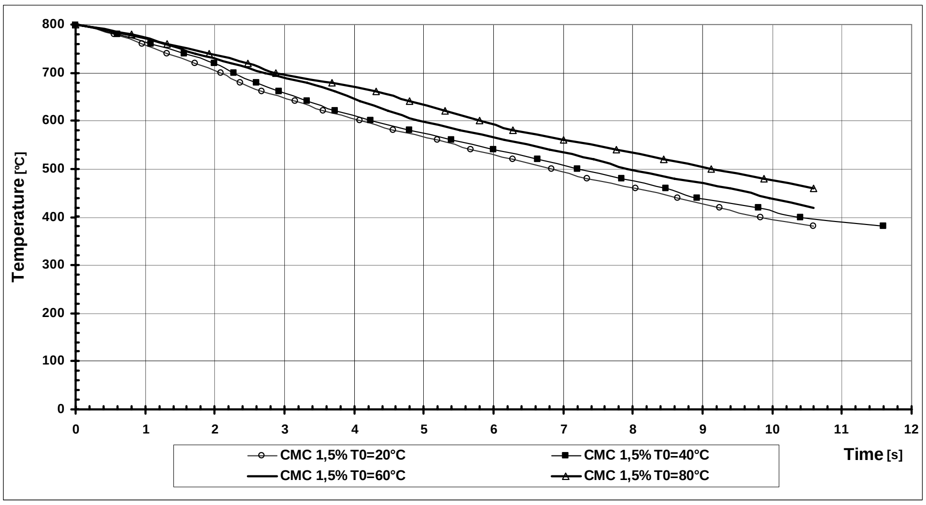

Fig. 7*. Cooling curves at different temperatures for CMC 1.5 % solution in water*

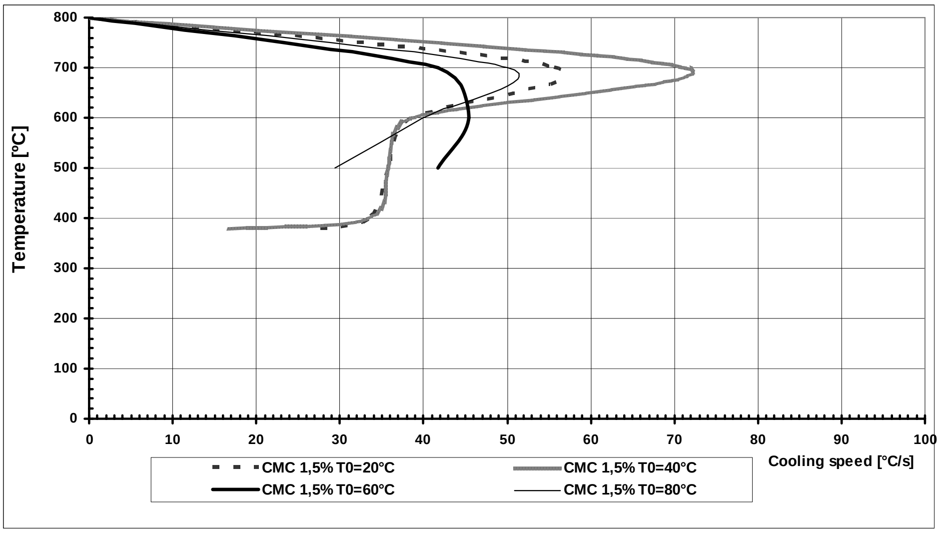

***Fig. 8.** Cooling speeds variation for CMC 1.5 % solution in water at different temperatures*

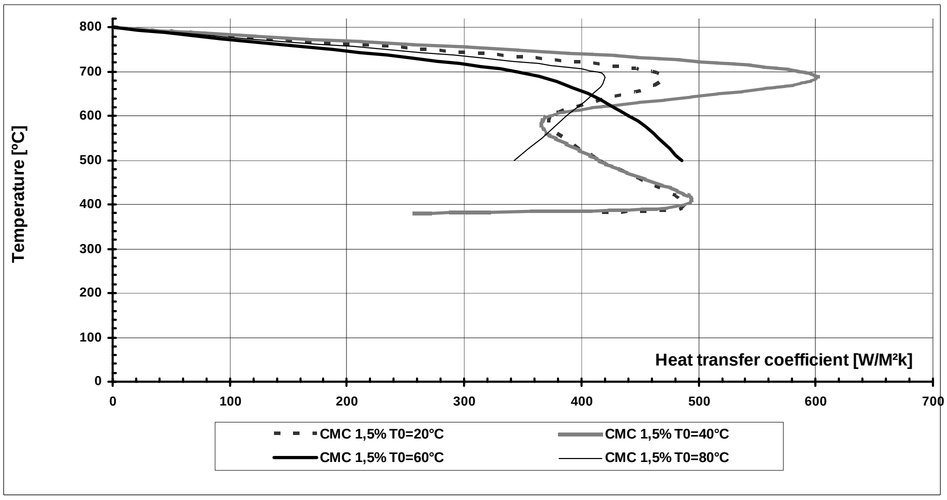

***Fig. 9**. Heat transfer coefficient variation for CMC 1.5 % solution in water*

3. Conclusions

1. An important impact on quenching environments cooling capacity is quenching medium temperature. This is seen both at the heat treatment of TT50 oil and the synthetic medium 1.5% CMC solution in water.

2. At 20 ° C heat treatment oil has the lowest average cooling rate and the lowest coefficient of heat transfer. Maximal cooling speed for TT50oil is at 80°C, V_r = 800 °C / s in the thermal range 600-500°C.

3. Compared to oil, for the 1.5% CMC solution in water the cooling speeds are 10 times smaller within the 10 seconds' period where measurements were made.

4. For carboxymethyl cellulose, medium rising temperature decreases maximum cooling speed, a maximum is met at the medium temperature of 40 °C, V_r = 71.43 C / s in the thermal range 800-700°C.

References

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