INFLUENCE OF THE THERMAL EXPANSION MISMATCH BETWEEN BODY AND GLAZE ON THE CRACK DENSITY OF GLAZED CERAMICS

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The genuine craquellé decor is created by a sufficient tensile stress in the glaze, which causes the glaze cracking during the cooling and creates the required crack-net. When slow cooling of the glazed ware is secured the characteristic crack-net is formed if the difference of the linear thermal expansion coefficient (ΔTEC) of the body and the glaze is in the range of (- 36 to - 65) × 10^{-7} K^{-1}. The cracks are so deep that they reach the body. The porous ceramic body that is characterised by the moisture expansion is not very suitable for the craquellé. In that case, the formation of cracks continues after cooling and additional thin cracks appear in the glaze. The results of tests of the crazing glazes showed that the intensity and design of cracks depend on the composition and combination of the glazes, too. Nice and interesting craquellés have been created in the prepared crazing glazes if ΔTEC (body-crazing glaze) was in the range of (- 33 to - 46) × 10^{-7} K^{-1}.

INTRODUCTION

Crazing glazes, called *genuine craquellé*, belong to the group of art glazes. This decor is characteristic by the rich net of the cracks, regularly distributed, over the surface and emphasized colouring [1]. The craquellé is intentionally developed for decoration purposes in opposite to unwanted cracking of the glazes due to the moisture expansion of the body (i.e. Haarriss).

The producers of glazes supply either the ready-made powdery crazing glaze or separately the "craquellé" admixtures and the glazes. The admixtures are added to a certain kind of base glazes. The crazing glazes and first of all the crack-developing admixtures have a coefficient of thermal expansion (*TEC*) of a high value. The extent of glaze crack depends very much on the ceramic body and on the difference between *TEC* body and glaze. These parameters of the bodies and the glazes are important and required by producers of ceramics.

The difference of thermal expansion of two different materials linked to each other - ceramics and glass - gives rise to stress in these materials. If the *TEC* of the glaze is any higher than that the *TEC* of the body tensile stress is created in the glaze. When the tensile stress is considerable and exceeds the strength of glaze, the glaze is cracking during the cooling process. The rich crack-net forms even during the final part of the cooling.

The coefficient of thermal expansion, the strength, the elasticity and others are the additive parameters of the glazes, i.e. these are functions of the composition of the material. The equation 1 expresses the calculation of the volume expansion coefficient of glass:

$$3\alpha = \beta = w_1\beta_1 + w_2\beta_2 + w_3\beta_3 + ...w_n\beta_n \qquad (1)$$

where α - linear thermal expansion coefficient (K^{-1}), β - volume thermal expansion coefficient (K^{-1}) , w_x - content of oxides in the glaze (wt.%), β_x - factor of the volume thermal expansion coefficient of the oxides, eventually of the glaze compound (K^{-1}) [1-4]. The value of the *TEC* varies according to the chemical composition of glaze from 50 × 10^{-7} to 200 × 10^{-7} K^{-1}. The value of the tensile strength of the common glazes is in the range of 40-160 MPa and the compression strength is about one order higher [1,2,5].

The limit stress in the glaze, which causes the cracking, is 15-20 MPa [5,6]; it corresponds to the value of the difference *TEC* between the body and the glaze, which is about 5 × 10^{-7} K^{-1}. The bigger the difference TEC, the richer the created crack-net.

The fast and preference cooling of the glazed surface in the final phase will increase the tensile stress in the glaze. This temporary stress forces the cracking of the glaze. This phenomenon is exploited for the production of craquellé decoration [1,2].

The cracks in the glaze reach down to the bodies and are liquid-permeable. There are several ways of how to protect the ceramic body against moisture penetration [1,2].

The present work deals with development of crack-nets in relation to the difference of thermal expansion of the body and the crackling glaze. It studies the influence of moisture expansion on the development of cracks. The cooling of the glazed ware was very slow to enable cracks forming the glaze as consequence of different expansion of the body and the glaze itself.

EXPERIMENTAL

The thermal linear expansion coefficient was measured on the blocks prepared from the powdery glazes and frits just as shown in table 1. The dilatation of the materials was measured using dilatometer E402 (Netzsch, Germany) at temperatures up to softening point of glazes; by use of instruments of a sensitivity of 250 μm; at a heating and cooling rate of 2°C per minute (simulating thus the cooling schedule of the firing at the factory). The *TEC* of glazes and body at a selected temperature range ($TEC_{(20-T)}$) were evaluated from the specimens (table 3). The results of the dilatation measurement were used to set up the recipes of crazing glazes (table 6).

The glazes were tested first of all on the slip body N (WBB Fuchs Keramische Massen, Germany) as well as on the fine plastic body J (ŽIAROMAT, a.s. KALINOVO, Slovakia) (table 1 and 6), (table 2) [7,8]. The ceramic biscuits N and J were fired in a gas-heated chamber kiln (VULCANO, Fratelli Ficola, Italy) at the following conditions: temperature 1030°C, firing time 24 hours.

The glazes were applied on the biscuits by spraying. The glaze samples were fired in the chamber kiln at the following conditions: firing time 20 hours; holding time 1 hours in the temperature zone at 980 to 1060°C according to the kind of glaze; the cooling rate from the temperature of 700 to 60°C was ca 1.5°C per minute. The cold specimens were painted by water suspension 5 hours after the firing. The cracks on the specimens were visualised by the iron oxide pigments. The evaluation of samples was repeated after 7 days and 14 days.

RESULTS AND DISCUSSION

The thermal expansion of tested glazes and glaze admixtures increases as follows: G4, G6, G5, P9, P7, G1, G8, P3 and P2 (figure 1 and table 3). The blocks prepared for dilatometry measurement of these glazes were without bubbles except for the blocks of glazes P2 and P3. The small bubbles could be removed by neither thermal treatment nor changing the preparation methods of blocks.

All glazes except for G1 showed high surface gloss. G1 is a light-brown glaze in which non-soluble white particles float towards to the surface thus forming the nacreous glitter. The other glazes and glaze admixtures are white and opaque. The transparency of glazes increases from G5, P7, G8, P9 to G6. P2 and P3 look like glass. The last two are low melting admixtures with significantly high value of *TEC*. Their addition into the basic glaze causes the cracking - crazing glaze. Owing to the low viscosity of the P2 and P3 admixtures at temperatures above 900°C the melt easily soaks into the ceramic body, interacts with it and creates a thick interlayer between body and glaze.

The producer of the glaze G8 recommends to use the P3 admixture to increase the *TEC* while the P7 and P9 admixtures for the covering ability. On the other hand, there is no suitable glaze recommended for the admixture P2. Therefore the suitable base glaze as well as the amount of admixture need to be found for the preparation of the crazing glazes.

Because the stress between the body and glaze generates during the cooling below the temperature T_g of glaze, the cooling curves are more important than the heating curves (figure 1). The dilatation differences between the glaze and body are shown in figure 2 and the average values of *TEC* for the temperature range (20-460, 20-500°C) are summarised in table 3.

The craquellé admixtures P2 and P3 with the highest values of TEC and with low T_g of about 450°C will increase significantly the *TEC* of the final glazes. In opposite, the addition of P9 and P7 will decrease the *TEC* and will increase the cover ability of the base glaze. The *TEC* values of G4 and G6 are comparable with the value of body N and therefore these glazes on this body will be under small compressive stress and they will not crack. However, the glazes, which will be under a stress of the same strength, but this time the stress will be tensile stress, will crack. *ΔTEC* between body and glaze are shown in tables 4 and 5.

The cracks in all glazes reach down to the body. In case of admixtures P2 and P3, when the excessively rich crack-nets are formed, the cracks colouring suspension can penetrate into the body thus harming it. The richness of the crack-net will be more emphasized with the increasing values of $|\Delta TEC$ (body-glaze)$|$. The *ΔTEC* (body-glaze) from -5×10^{-7} up to 18×10^{-7} K^{-1} generate tensile to compression stress in the range -20 to 71 MPa. Glazes under such low stress did not crack neither during nor immediately after cooling. However, already one week after firing typical haarrisse appeared in the G5 glaze, which was under a stress of -22 MPa. Several days after firing cracks were observed and sparse net of cracks was formed in the G6, P9, P7 and G5 glazes on the body J. It is caused by the considerable moisture expansion of this body (0.1 %) [8]. The volume increase of body leads to the gradual increase of the tensile stress, and it is followed by the formation of the slight haarrisse cracks.

Table 1. Basic characteristic of glazes and glaze admixtures; preparation of the glaze blocks for dilatometry; G - glaze, P - admixture.

labelling of glaze producer	characteristic • colour/covering ability/ (composition) • firing temperature	preparation of block		size of block (mm)
G1 glaze CERDEC AG (Deutsch)	• light beige, iridescent, semi-cover/ frit 50 559 GY+Al(OH)$_3$ + MoO$_2$+TiO$_2$ • 1020°C	glaze was molten in melting-pot at 1000°C/1.5 h (tempered at 900°C)	Blocks were pulled from the melt, blocks were reheated on ceramic waffle protected by kaolin to the temperature of 700 or 900°C and 15-30 min. with subsequent cooling at a rate of 2°C/min.	48 × ⌀6
P2 craquellé admixture FERRO (Holland) - addition 10-20% into the basic glaze develops the craquellé	• transparent, without colour • 1000-1060°C	glaze was molten in melting-pot at 980°C/ 1 h (tempered at 700°C)		34 × ⌀4
P3 craquellé admixture FERRO (Holland) - addition 50% with 50 % of P9 into the basic glaze	• transparent, without colour • 950-990°C	glaze was molten in melting-pot at 980°C/ 1 h (tempered at 700°C)		35 × 4
G4 glaze FERRO (Holland)	• white, matt, cover (rit 23045+ frit Fc 490+ nefeline+ kaolin) • 1000 - 1060°C	glaze was molten in ceramic tank at 1050°C/ 1.5 h	Glaze placed in tanks having inner surface covered with kaolin were cooled at a rate 2°C/min, the blocks were cut from the glazes after cooling.	45 × 10 × 8
G5 glaze REIMBOLD & STRICK (Italy)	• glossy, white, semi-cover • 960 - 1060°C	glaze was molten in ceramic tank at 1020°C/ 1.5 h		50 × 8 × 8
G6 glaze FERRO (Holland)	• white matt, semi-cover • 980 - 1050 °C	glaze was molten in ceramic tank at 1010°C/ 1.5 h		41 × 10 × 8
P7 admixture FERRO (Holland) - addition 50% with 50 % of P3 (or P9) into the basic glaze	• white, glossy, semi-cover SiO$_2$-B$_2$O$_3$-Al$_2$O$_3$-Na$_2$O-K$_2$O–CaO • 980 - 1015°C	glaze was molten in ceramic tank at 1000°C/ 1.5 h		38 × 10 × 6
G8 basic glaze fa FERRO (Holland) - glaze for the admixtures P3, P7 a P9	• white, glossy, semi-cover • 1000 - 1060 °C	glaze was molten in ceramic tank at 1000°C/ 1.5 h		50 × 10 × 8
P9 admixture FERRO (Holland) - addition 50% with 50 % of P3 (P7) into the basic glaze	• white, glossy, cover SiO$_2$-B$_2$O$_3$-ZrO$_2$-Al$_2$O$_3$-Na$_2$O-CaO-MgO-ZnO) • 960-1000°C/	glaze was molten in ceramic tank at 1010°C/ 1.5 h		49 × 10 × 6

Table 2. Basic characteristic of tested biscuits [7,8].

body producer	composition	firing temperature (°C)	basic physical parameters		
			water absorption (%)	moisture expansion 100 l/l_0 (%)	$TEC_{(T2-T1)}$ 10^{-7} (K^{-1})
plastic fine grained mass body (J) Kachle, KERKOtherm, a.s. Košice	3 kinds of Slovak clays and 31 wt% chamotte; grain size with a maximum ratio of 4 wt.% of sizes above 0.09 mm	980-1060	18 -21	0.100	49.5 (460-20°C) 50 (500-20°C)
slip casting mass body (N) WBB Fuchs Keramische-Massen, Germany	granulate GW/K-10/SK, low absorbing fire clay; weight ratio – 60 : 40	1000-1100	13-17	0.050	62 (460-20°C) 66 (500-20°C)

Table 3. Coefficient of linear thermal expansion of bodies, glazes and glaze admixtures for the temperature ranges (T_2-T_1) and T_g - transformation temperature of glazes and admixtures.

	mass	*TEC* (T_2-T_1) 10^{-7} (K^{-1})		T_g (°C)	$TEC_{(20\text{-}T_g)}$ 10^{-7} (K^{-1})
		20 – 460°C	20 – 500°C		
body	plastic body J	49.5	50		
	cast body N	62	66		
glaze /admixture	G4	59	60	585	64
	G5	65.5	69	520	72
	P9	64.5	66.5	570	73
	P7	66	67.5	590	73
	G6	63	63	575	73
	G1	78.5	84	515	85
	G8	98	100.5	540	107
	P3	128	-	465	122
	P2	166	-	445	155

G – glaze, P – admixture promoted cracking and/or increased cover ability

Table 4. Difference between the dilatation of the body *J* and glaze or glaze admixture (%), the difference of *TEC* (body-glaze) for the temperature ranges; (negative sign indicates the tensile stress in the glaze).

glaze	temperature range (°C)							cracks 7 days after firing
	460-20	500-20	T_g-20	460-20	500-20	T_g-20	T_g-20	
	$\Delta\left(\frac{\Delta l_{(T2\text{-}T1)}}{l_o}\right)_{body\ \ glaze}$ 100 (%)			$\Delta TEC_{(T2\text{-}T1)}$ (body J- glaze) 10^{-7} (K^{-1})			σ stress in glaze (MPa) [4,5]	
P2	-0.516	-	-0.443	-117	-	-105,5	-326	CC
P3	-0.349	-	-0.343	-79,5	-	-78	-252	CC
G8	-0.214	-0.242	-0.281	-48,5	-50,5	-54	-206	C
G1	-0.127	-0.163	-0.194	-29	-34	-38	-140	C
G5	-0.070	-0.091	-0.118	-16	-19	-23,5	-86	SC
P7	-0.074	-0.085	-0.092	-17	-17,5	-16,5	-68	SC
P9	-0.067	-0.078	-0.090	-15	-16	-16,5	-66	SC
G6	-0.060	-0.068	-0.088	-14	-14	-16	-63	SC
G4	-0.040	-0.048	-0.028	-9	-10	-5	-20	0

0 – without crack, SC – sparse net of cracks, C- characteristic the crack-net for the crazing glaze, CC- very rich net of cracks (number of areas bounded by cracks higher than 25 / cm^2)

Table 5. Difference between the dilatation of the body N and glaze or glaze admixture (%), the difference of *TEC* (body-glaze) for the temperature ranges; (negative sign indicates the tensile stress in the glaze).

glaze	temperature range (°C)							cracks 7 days after firing
	460-20	500-20	T_g-20	460-20	500-20	T_g-20	T_g-20	
	$\Delta\left(\frac{\Delta l_{(T2\text{-}T1)}}{l_o}\right)_{body\ \ glaze}$ 100 (%)			$\Delta TEC_{(T2\text{-}T1)}$ (bodyN- glaze) 10^{-7} (K^{-1})			stress in glaze (MPa) [4,5]	
P2	- 0.456	-	- 0.397	-104	-	-88	-272	CC
P3	- 0.289	-	- 0.289	-65.5	-	-65.5	-212	C
G8	- 0.154	- 0.166	- 0.184	-35	-34.5	-35.5	-136	SC
G1	- 0.067	- 0.087	- 0.104	-15	-18	-20	-74	SC
G5	- 0.010	- 0.015	- 0.029	-2.5	-3	-6	-22	HC
P9	- 0.008	- 0.002	0.025	-2	-0.5	4.5	18	0
P7	- 0.014	- 0.009	0.038	-3	-2	7	29	0
G6	-0.000	0.007	0.041	0	1	7.5	30	0
G4	0.020	0.028	0.102	4.5	5.8	18	71	0

0 – without crack, HC – haarriss, SC – sparse net of cracks, C- characteristic the crack-net for the crazing glaze, CC- very rich net of cracks (number of areas bounded by cracks higher than 25 / cm^2)

Table 6. List of crazing glazes, $TEC_{(20\text{-}500°C)}$ of glazes and ΔTEC (body - glaze).

No. sample	composition of glaze	$\Delta TEC_{(20\text{-}500)} \times 10^{-7}$ (K^{-1})	body N	
			Δ TEC(body–glaze) 10^{-7} (K^{-1})	intensity of crack-net
1	20 % P3 + 80 % G8	106	-40	4.
2	5 % P3 + 90 % G8+ 5 % P7	100	-34	2.
3	10 % P3 + 80 % G8+ 10 % P7	100	-34	3.
4	10 % P3 + 80 % G8+ 10 % P9	100	-34	3.
5	20 % P3 + 70 % G8+ 10 % P9	102	-36	3.
6	30 % P3 + 60 % G8+ 10 % P9	105	-39	3.
7	30 % P3 + 60 % G6+ 10 % P9	83	-17	2.
8	40 % P3 + 50 % G6+ 10 % P9	89	-23	2.
9	50 % P3 + 50 % G6	95	-29	2.
10	20 % P3 + 80 % G1	93	-26	2.
11	20 % P2+ 80 % G1	99	-33	3.
12	5 % P2+ 85 % G8+ 10 % PX	100	-34	3.
13	10 % P2+ 90 % G6	74	-8	1.
14	20 % P2+ 80 % G6	83	-17	2.
15	40 % P2+ 60 % G6	103	-37	3.
16	50 % P2+ 50 % G6	112	-46	4.
17	10 % P2+ 90 % G5	78	-12	1.
18	20 % P2+ 80 % G5	87	-21	2.
19	40 % P2+ 60 % G5	105	-39	3.
20	50 % P2+ 50 % G5	115	-48	4.
21	20 % 90 161 + 80 % G5	70	-4	1.
24	P9 (20 % P3 + 80 % G8)*	106	-40	3.
25	G4 (20 % P3 + 80 % G8)*	106	-46	3.
26	G6 (20 % P3 + 80 % G8)*	106	-41	3.

* $\Delta TEC_{(T1\text{-}T2)}$ – the body was glazed first time with the glaze (P9, or G4 or G6) and immediately then with the crazing glaze No. 1 (20 % P3 + 80 % G8)

1. - without cracks or with the hairline cracks or with very sparse net of cracks
2. - very nice but not very rich net of cracks in the glaze
3. - very nice rich crazing glaze
4. - profuse crazing or ungainly glaze

The optimally rich and homogeneous net of straight cracks characteristic for the craquellé decor was created in the glazes on the body N if *ΔTEC* (body-glaze) is in the range -36×10^{-7} up to -65×10^{-7} K^{-1}. Similar crack-net was formed on the body J when $|\Delta TEC$ (body-glaze)$|$ was about 10×10^{-7} K^{-1} lower. The crack-net will become too rich if the *ΔTEC* (body-glaze) will exceed the above limit. At the same values of *ΔTEC* (body-glaze) the crack-net on body J will be always richer comparing to body N because of its higher moisture expansion (table 2). The data of the stress (σ) in tables 4 and 5 refer only to the pure difference of *TEC* of the body and glaze without any influence of the moisture expansion of bodies.

The cracking stimulated by the moisture expansion can be inhibited by the fast cooling of the ware in the final firing, which evokes the increased cracking (figure 3). Such treatment will release the tensile stress and the glaze is less sensitive to the moisture cracking.

The figure 3 demonstrates the dilatation differences between the body N and base glaze G5 (100 %), glaze G5 with 40 % of admixture P2 and pure P2 (100 %).

Of course, the richness of the crack-net depends on the *ΔTEC* (body-glaze), the rate of cooling of the glaze surface, shape of body and thickness of glaze. The thinner the layer of glaze the richer the crack-net is and vice versa. Specimens shown in figure 4 were cooled slowly and uniformly, the glaze thickness was 200-250 μm.

The results of dilatation measurements of glazes and body shown in table 5 were used for recipe of mixing ratios of the crazing glazes - craquellé. These glazes were applied on the body N and the average $TEC_{(20\text{-}500)}$ of glaze and *ΔTEC* are shown in table 6.

A characteristic craquellé-net was formed on the body N if the *ΔTEC* (body-glaze) was in the range (-30 to -45) $\times 10^{-7}$ K^{-1} (figure 5b). The stress in the glaze caused by the *ΔTEC* (body-glaze) difference of (-20 to -30) $\times 10^{-7}$ K^{-1} evokes the sparse, uniform crack-net, which is acceptable for and looks nice on most of wares (figure 5). The *ΔTEC* (body-glaze) below -20×10^{-7} K^{-1} are insufficient for the formation of satisfactorily rich crack-net in the glaze (figure 5a). On the other hand, excessive rich nets are formed if the *ΔTEC* (body-glaze) are higher than -45×10^{-7} and unacceptable above -50×10^{-7} K^{-1}. (figure 5d).

Although the richness of crack-net is satisfactory at the *ΔTEC* (body-glaze) (-30 to -40) × 10^{-1} K^{-7} the nice appearance is not assured in all cases. Specimen 1 (table 6) is not nice at a glance due to the intersecting thin and thick cracks. But if this glaze (specimen 1) was applied on the layer of raw glaze G6, G4 or P9 spraying it on the body N, a beautiful net appeared (figure 6). The P9, G5 and G4 have nearly the same value of *TEC* as body N. The difference between *TEC* of lower and upper glaze layer is -40 to -46 × 10^{-7} K^{-1}. The idea of using the double layer was aimed to prevent the formation of the deep and wide cracks.

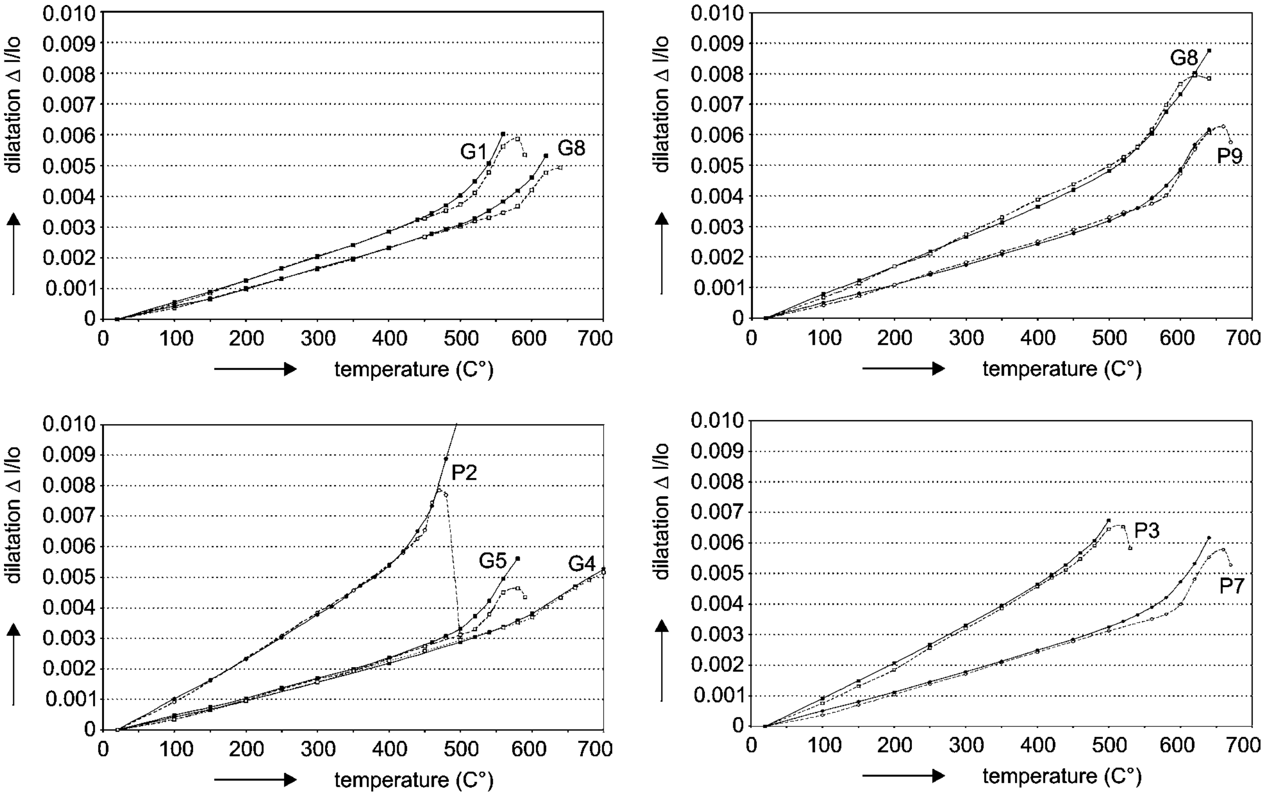


Figure 1. Dilatation curves of glazes and glaze admixtures; heating (- - - -) and cooling (——) at a rate of 2°C/min. Cooling dilatation curves are re-calculated with respect to sintering shrinkage of samples.

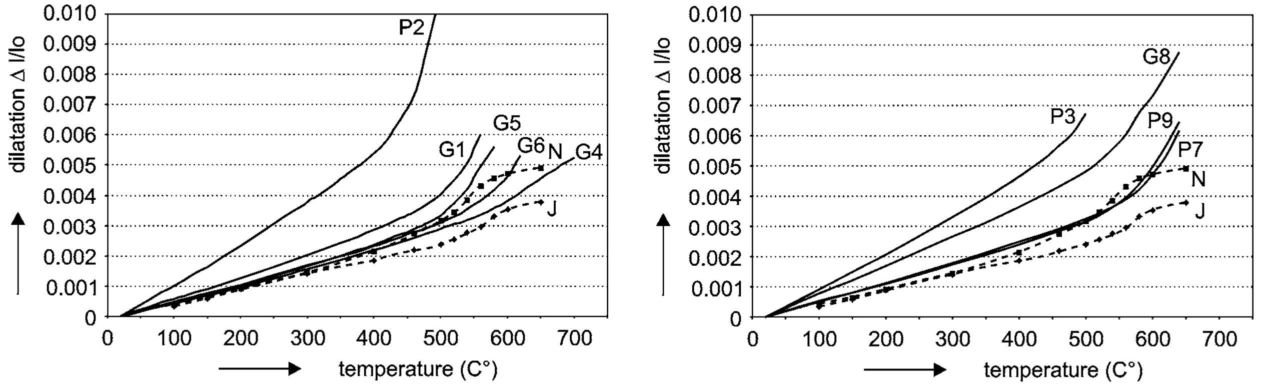


Figure 2. Linear thermal expansion of the glazes and glaze admixtures increased the *TEC* and promoted the cracking of glazes compared with the bodies J and N (cooling curves).

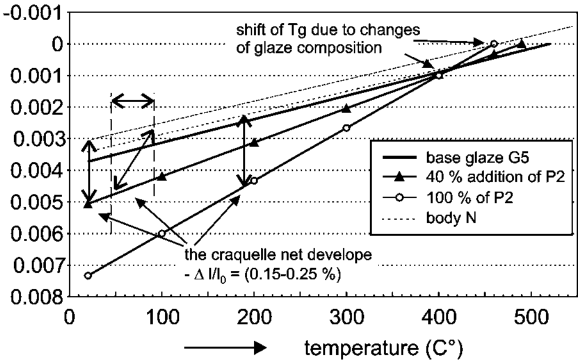


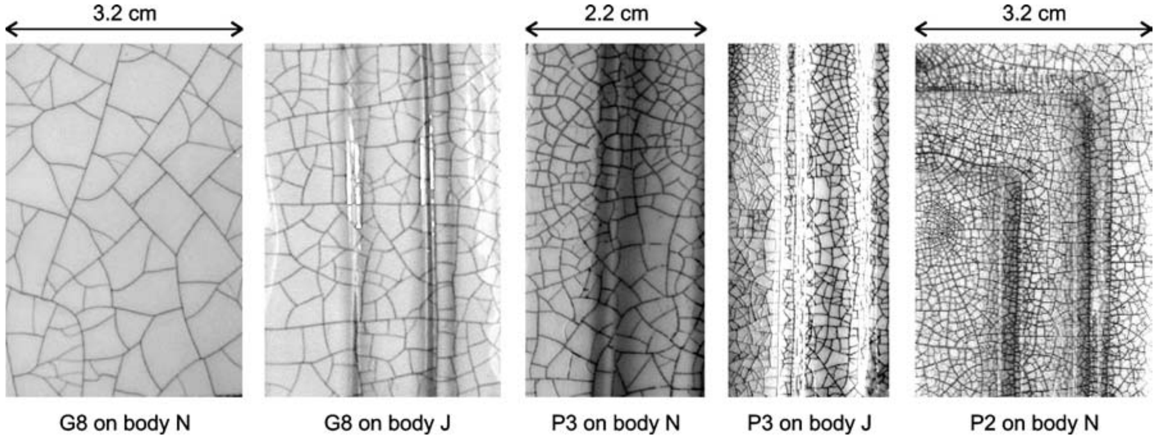
Figure 3. Comparison of uniform and non-uniform cooling of the glaze and the body. Non-uniform cooling increases the difference value of the $100 \times \Delta l/l_0$ (%) between the body and glaze.

CONCLUSION

The permanent stress in the body and glaze is raised by the difference of their dilatation behaviour. The rich crack-net of the crazing glaze depends on the value of the tensile stress in glaze generated during the cooling ware in the final stage of the cooling. If the glaze surface is cooling faster than the body the tensile stress temporarily increases in the glaze. The crazing effect is thereby more intensive and richer crack-net is created.

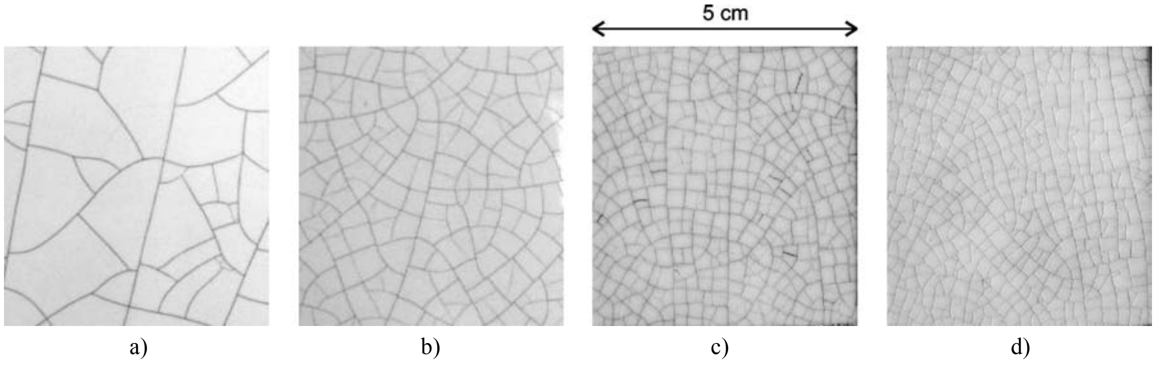
During the uniform cooling of the ware to obtain a sufficiently rich crack-net, the craquellé decor, the difference *TEC* between the body and glaze must be (-36 to -65) × 10^{-7} K^{-1}, which creates a tensile stress of about 140 - 210 MPa in the glaze.

With porous bodies, where moisture expansion is a characteristic feature, the value of tensile stress in the glaze some days after firing is higher than the calculated value. This means that moisture expansion increases tensile stress in the glaze. The crack-net on the body J is always richer than on the body N because the moisture



G8 on body N
G8 on body J
P3 on body N
P3 on body J
P2 on body N

Figure 4. Glaze G8 on the body N ($\Delta TEC_{(20\text{-}540)}$ - 35 × 10^{-7} K^{-1}) and the body J ($\Delta TEC_{(20\text{-}540)}$ - 54 × 10^{-7} K^{-1}); glaze admixture P3 on the body N ($\Delta TEC_{(20\text{-}540)}$ - 66 × 10^{-7} K^{-1}) and the body J ($\Delta TEC_{(20\text{-}460)}$ - 80 × 10^{-7} K^{-1}); glazed admixture P2 on the body N ($\Delta TEC_{(20\text{-}460)}$ - 104 × 10^{-7} K^{-1}) .



a)
b)
c)
d)

Figure 5. Specimen No. 17 with the $\Delta TEC_{(20\text{-}500)}$ = - 12 × 10^{-7} K^{-1} (a), No. 18 with the $\Delta TEC_{(20\text{-}500)}$ = - 21 × 10^{-7} K^{-1} (b), No. 19 with the $\Delta TEC_{(20\text{-}500)}$ = - 39 × 10^{-7} K^{-1} (c) and No. 20 with the $\Delta TEC_{(20\text{-}500)}$ = - 48 × 10^{-7} K^{-1} (d) on the body N.

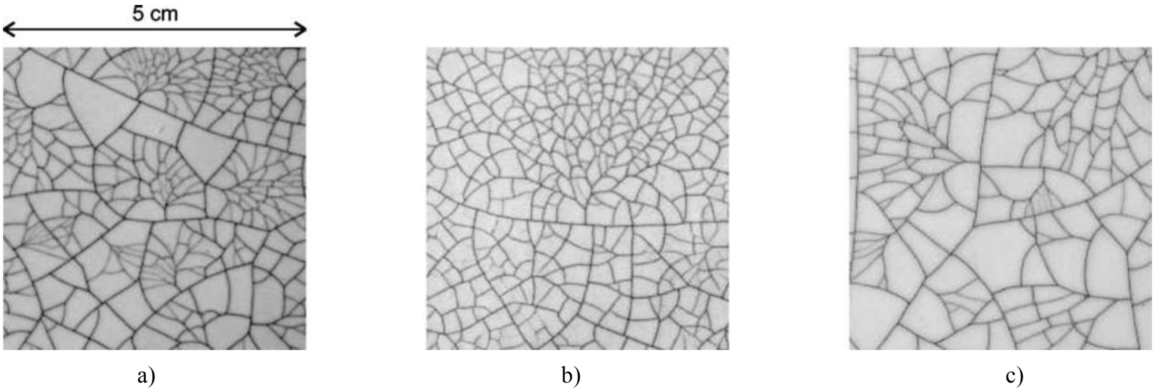


Figure 6. Specimen No.1 (20% P3 + 80% G8 in table 6) applied on the layer of the green glaze P9 (a), G4 (b) and G6 (c) on the body N; differences between the Δ*TEC* priming glaze and top glaze are (a) - 40×10^{-7} K^{-1}, (b) - 46×10^{-7} K^{-1} a (c) - 41×10^{-7} K^{-1}. The *TEC* of glaze P9, G4 and G6 are similar than the *TEC* of body N.

expansion of the body J (0.1%) is higher than that of body N (0.05%). Therefore the sparse crack-net is unstable, after a certain time new thin cracks are created.

If the prepared crazing glazes achieved a Δ*TEC* (body-glaze) of about (-33 to -46) × 10^{-7} K^{-1}, very nice craquellés were mostly created.

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VPLYV ROZDIELU TEPLOTNEJ ROZŤAŽNOSTI ČREPU A GLAZÚRY NA TRHLINKOVANIE GLAZÚRY

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Podstatou vzniku pravého krakele je vyvolať v glazúre tak veľké napätie v ťahu, aby glazúra výrazne popraskala už v priebehu chladenia. Pri dodržaní rovnomerného chladenia glazovaného výrobku sa požadovane hustá sieť trhlín v testovaných glazúrach a prísadách do glazúr dosiahla, ak rozdiel medzi koeficientom teplotnej rozťažnosti - *ΔKTR* (črep - glazúra) bol z rozsahu -36×10^{-7} K^{-1} až -65×10^{-7} K^{-1}.

Nerovnomerné, rýchlejšie ochladzovanie glazúry s vyšším *KTR* oproti *KTR* črepu podporí rozvoj prasklín v procese chladenia. Vlhkostný nárast črepu, ktorý môže nastať až po výpale a ktorý je u póroviny bežný, vyvoláva dodatočný rast ťahového napätia v glazúre. Pri prekročení pevnosti glazúry sa prejavuje rozvojom trhlín.

Z testovaných dvoch pórovinových črepov s rozdielnym vlhkostným nárastom je pre dekorovanie krakele glazúrami nevhodný črep s vyšším vlhkostným nárastom (0,1 %). Sieť prasklín v glazúre na tomto črepe je veľmi nestála. Praskliny v glazúre, ktoré vzniknú neskôr po ochladení výrobku sú vizuálne odlišné od trhlín vytvárajúcich sa v procese chladenia. Trhliny sú jemnejšie a ich vznik po vyfarbení vzoru je nežiaduci.

Výsledky testov kombinácie testovaných základných glazúr s rôznym prídavkom krycej, resp. matnej glazúry a krakele prísady ukázali, že intenzita prasklín a kresba trhlín v glazúre je nie len funkciou *KTR* glazúry ale závisí aj od skladby glazúry. Charakteristická sieť trhlín pre krakele dekór, aj vzhľadovo pekná, sa vytvorila u navrhnutých receptúr „krakele glazúr“ už pri *ΔKTR* (črep - glazúra) od -33 až -46×10^{-7} K^{-1}. V prípade navrhnutých krakele receptúr je vymedzený rozsah intervalu *ΔKTR* užší ako je pri aplikácií základných glazúr a čistých prísad do glazúr.