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*surgical cement, ceramic,*
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# METHOD OF CONTRACTION AND POLYMERISATION TEMPERATURE TESTING FOR SURGICAL CEMENT

This work concentrates on the developing a method of the contraction and polymerisation temperature testing for the surgical cement. The linear contraction and maximum polymerisation temperature values have been determined for the pure Palacos R cement and for the same cement with $Al_2O_3$ admixture. The investigations were performed into metal mould at initial temperature 19 $^0$C and 37 $^0$C. Basing on the examination results it can be stated that on the contraction and polymerisation temperature the following factors have the influence:

– temperature of the mould,
– kind of the admixture,
– a size of the admixture particles.

## 1. INTRODUCTION

A variety of bone cements are used in bone surgery. They are the self-polymerisationed acrylic substances formed during the surgical procedure from mixture of powdered polymer and liquid monomer. Polymethyl methacrylate (PMMA) is usually the polymer component and methyl methacrylate (MMA) is the liquid one [1-5,7]. On account of difference between the mass density of monomer and polymer amounted to appropriately 0,99 g/cm$^3$ for MMA and 1,20 g/cm$^3$ for PMMA, the polymerisation occurs with the volume contracting, producing the contraction amounted 1-5% [4,7]. This fact perhaps has an influence on the cemented arthroplasty durability [3].

The polymerisation is an exothermic process and in the case of the polymerisation of MMA to PMMA the heat of reaction is emitted (about 13 kcal/mol). By that reason the temperature of the formed surgical cement increases. The increase of the polymerisation temperature is the function of the heat generated and carried away during the process of the polymerisation. The quantity of the heat emitted depends on the monomer concentration in the mass of cement, however the heat emission rate depends on the initially inhibiting system and the temperature of the cement mass.

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From medical angle the high polymerisation temperature of the bone cement, considerably exceeded the protein coagulation temperature, can cause the necrosis of the tissues [4,5,7].

To improve the useful properties of surgical cements the investigations of the chemical and physical properties changes on account of the chemical composition and structure modification are carried.

This work concentrates on the developing a method of the contraction and polymerisation temperature testing for the surgical cement. The linear contraction and maximum polymerisation temperature values have been determined for the pure cement on the PMMA base and for the same cement with ceramic $Al_2O_3$ admixture. The research was performed into metal mould at initial temperature 19 $^0$C and 37 $^0$C.

## 2. MATERIAL AND METHOD

Palacos R surgical cement without any admixtures and that with ceramic admixture was used as test material. The following kinds and quantities of admixtures per 40,0 g of powdered cement component were used:

A – $Al_2O_3$ powder of 0,3 μm fraction (6 g, which is 13% in volume fraction),
B – $Al_2O_3$ powder of 10-20 μm granulation (6 g, which is 13% in volume fraction).

The system for the analysis of the composite casting solidification and free linear contraction was planed and made in the Metal Alloy and Composites Engineering Chair in Silesian University of Technology [6]. The test stand, marked of the symbol: SL-PG1, consist of the base plate with the fixed strain gauges, the experimental metal mould at the controllable initial temperature, the multifunctional measuring set ME 8520 and the computer system for the registration, analysis and visualisation of the obtain results and dependencies. The temperature of the setting cement has been measured by means of the thermoelement NiCr-NiAl into the thermal centre of the sample. During the investigations the characteristic points on the self-cooling curve $T = f(\tau)$ and on the linear contraction curve $S = f(\tau)$ have been determined. The fluid cement has been inserted into metal mould at initial temperature 19 $^0$C and at the temperature increased to 37 $^0$C. This two alternative tests were selected, because during the surgical operation cement implantation is in contact directly with the cold metal prosthesis at the room temperature (19 $^0$C) on the one hand, and with the living bone at the human temperature (about 37 $^0$C) on the other hand. In the course of the tests this two boundary conditions were simulated separately. The linear contraction measurements of the all materials have been registered for 6 to 9 hours [1].

## 3. RESULTS

Figures 1 to 3 present the exemplary diagrams of the change of the polymerisation temperature and linear contraction in course of time for Palacos R cement with $Al_2O_3$ admixtures. The values of the maximum polymerisation temperature and values of the final linear contraction, as read from the diagrams, for the tested materials have been presented in Figures 4 and 5 [1].

It can be stated that the ceramic admixture into the surgical cement on the PMMA base decreases the linear contraction of the samples, but it doesn't lower the maximum polymerisation temperature of the modified cement, and even it increase in some causes this temperature (Fig. 4a).

The investigations have been shown that the initial temperature of the mould has significant influence upon the temperature of the cement polymerisation. Into the mould at the initial temperature 19 $^0$C the maximum polymerisation temperature was about 39,6 $^0$C, when by initial temperature 37 $^0$C the maximum polymerisation temperature reached 109,2 $^0$C (Fig. 1,2,3,4a and b).

Increasing the initial temperature of the mould to 37 $^0$C was profitable for the linear contraction of Palacos R cement as well as with and without $Al_2O_3$ admixture, decreasing it to about 20% (Fig. 1,2,3,5a and b) [1].

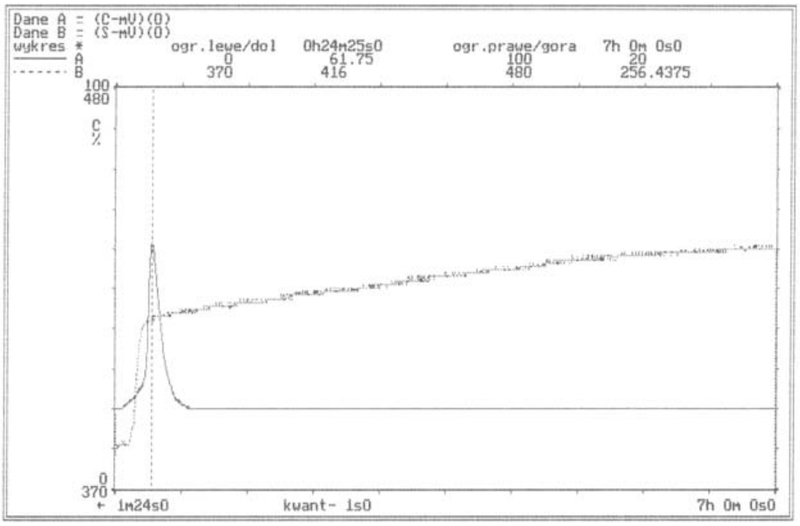



Fig.1. Change of the polymerisation temperature and linear contraction in course of time for Palacos R cement with $Al_2O_3$ (powder of 10-20 μm granulation) into metal mould at initial temperature 19 $^0$C.

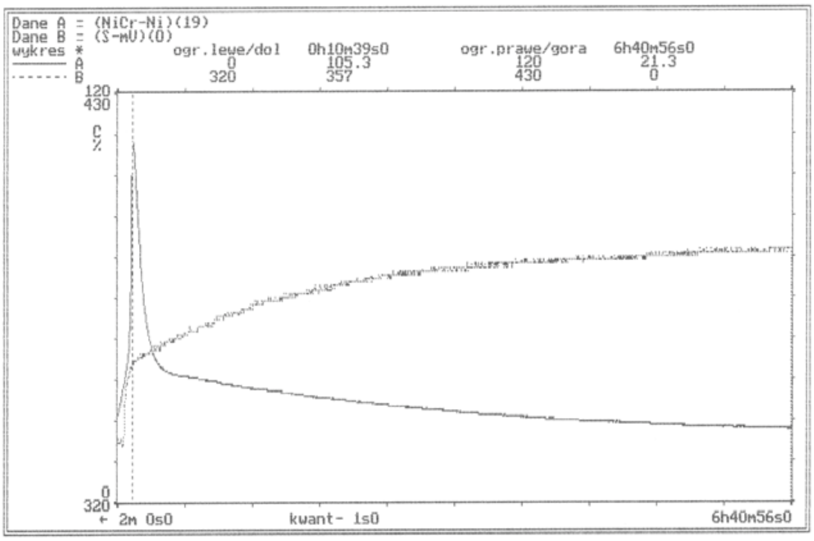



Fig.2. Change of the polymerisation temperature and linear contraction in course of time for Palacos R cement with $Al_2O_3$ (powder of 10-20 μm granulation) into metal mould at initial temperature 37 $^0$C.

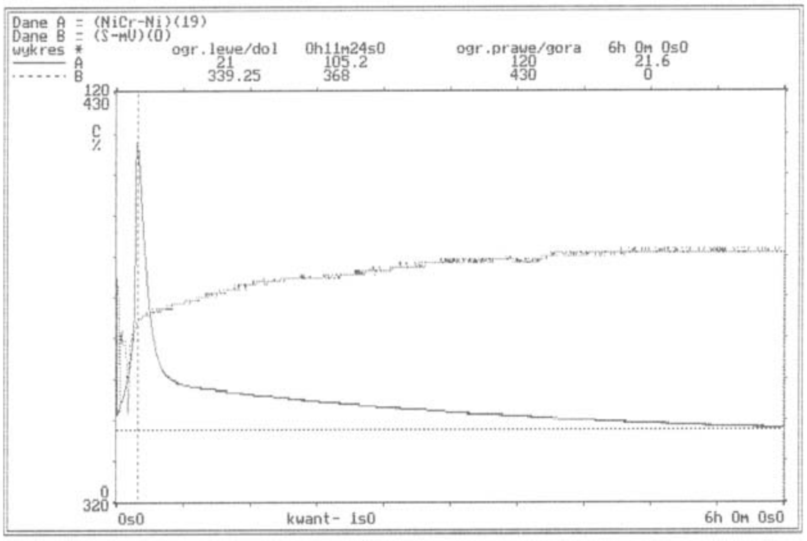
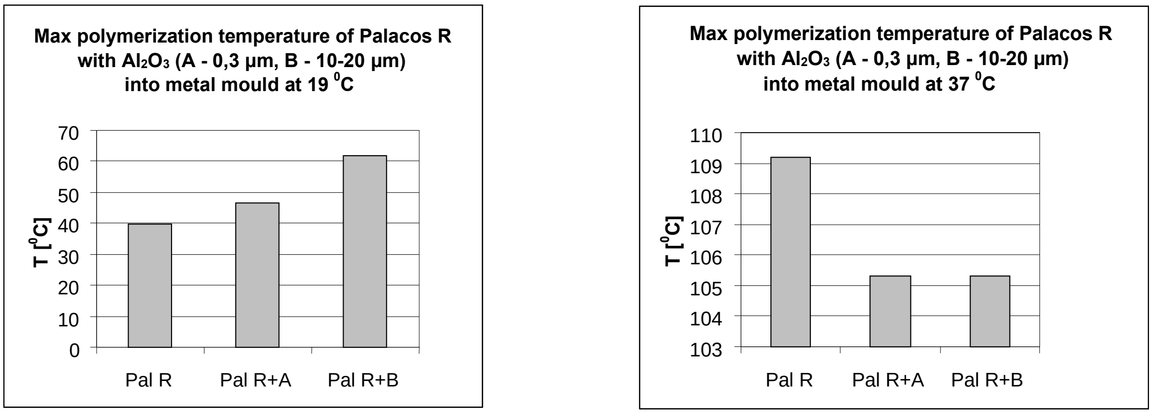
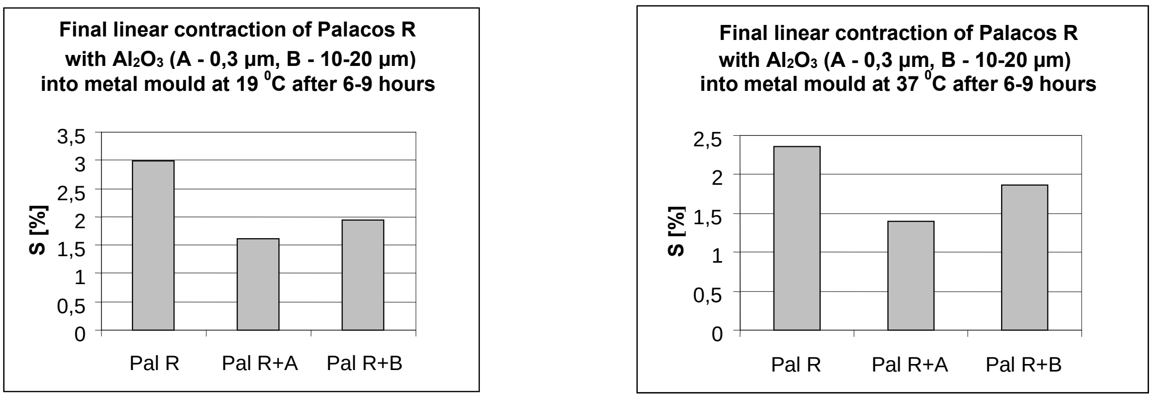



Fig.3. Change of the polymerisation temperature and linear contraction in course of time for Palacos R cement with $Al_2O_3$ (powder of 0,3 μm fraction) into metal mould at initial temperature 37 $^0$C.




a b

Fig.4. Maximum polymerisation temperature of Palacos R cement with $Al_2O_3$ into metal mould at initial temperature 19 $^0$C (a) and 37 $^0$C (b) [1].




a b

Fig.5. Final linear contraction of Palacos R cement with $Al_2O_3$ after 6-9 hours into metal mould at initial temperature 19 $^0$C (a) and 37 $^0$C (b) [1].

## 4. CONCLUSIONS

The obtained results have been shown, that the presented testing method can be apply to the analysis of the polymerisation temperature and linear contraction in course of time for the modified surgical cements.

Basing on the examination results it can be stated, that on the contraction and polymerisation temperature values the following factors have the influence:

– a temperature of the mould,
– a kind of the admixture material,
– a size of the admixture particles.

The better simulation of the human organism reaction on the surgical cement contraction and maximum polymerisation temperature it can obtain by the way of the corresponding mould work out.

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