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Computer aided process of dimensional distortion determination of bounded plaster sandmix

M. Pawlak[a],*, Z. Niedźwiedzki[a]
[a]Department of Materials Technology and Production Systems, Technical University of Lodz, Stefanowskiego 1/15, 90-924 Lódz, Poland
*Corresponding author. E-mail address: marek.pawlak @p.lodz.pl

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Abstract

A computer program allowing calculation of dimensional changes of mould made of silica-gypsum composition in process of its heat treatment and preparation for molten metal casting is presented in this paper. The composition of the mixture and casting temperature to obtain cast of predetermined dimensions can be calculated using presented software. The base for program elaboration were the results of dilatometric test of bounded plaster sandmix composed of half hydrate α-$CaSO_4 \cdot 0{,}5H_2O$ of various silica SiO_2 ratio (0, 30, 40, 50, 60, 70 and 98%). Approximation was carried out in the range of temperatures 100÷800°C.

Keywords: Innovative foundry technologies and materials, Precision casting, Plaster mould, Dilatation

1. Introduction

Plaster, as a mould material for preparation casts of medium melting temperature alloys had many advantages. It is a material which perfectly projects complicated casting shapes assuring simultaneously good dimensional accuracy and smooth surface. However it brings lot of technological problems. The reasons for that are mainly phase transformations during heating and bounding. These transformations are connected with crytal lattice rebuilding and thus changes of density. This causes high thermal stresses leading even to mould cracking [1].

Independently on above described problems, advantages of this technology, especially with use of underpressure, make wide application of it in jewellery, art foundry, prosthetics and low series casting of high quality [1].

The results of phase transformations can be soften by addition of components compensating transformations in plaster (silica, anhydrite) and high temperature treatment leading to anhydrite II creation characterized by linear expansion [1, 3, 4].

Thus, the basic problem is to determine appropriate, the most advantageous composition of the plaster sandmix at which it is possible to obtain predetermined dimensional changes of bounded sandmix and as low as possible phase stresses during thermal treatment. The next problem is to find out the temperature of the mould the best from the viewpoint of dimensional accuracy of the mould and therefore made cast [1, 2, 5, 6].

It is very time consuming and difficult to define listed above parameters. The work task of elaborated computer program is therefore to calculate mould dimensions made of silica-plaster composition just before casting.

2. Results of dilatometric measurements of the block made of various plaster compositions during cooling phase and theirs approximation

Testing blocks of dimensions ø 7x35 mm made of dihydride plaster α-$CaSO_4 \cdot 2H_2O$ with silica percentage 0, 30, 40, 50, 60, 70 i 98% were investigated. Materials and methodology were described in details in [1].Data for computer program were taken raw with special emphasis given to testing blocks cooling characteristics. Full data are presented in fig. 1

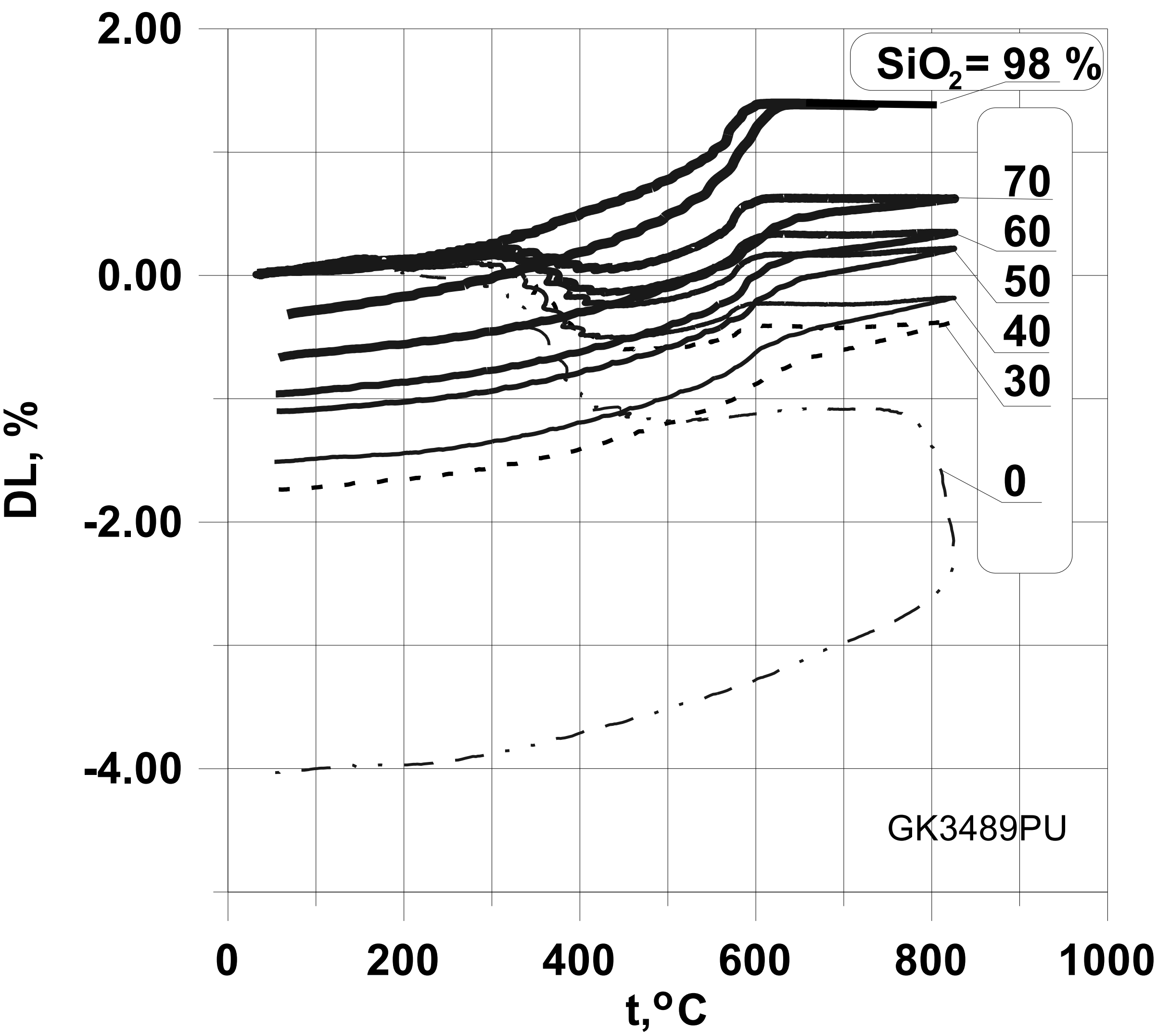

Fig. 1. Relative dimensional change DL vs testing block temperature during heating and cooling

The analysis of presented in fig. 1 dependence show that phase transformations of the components hale significant influence on final dimensions of tested sample heated and cooled down. This dependence is partially of additive character because of different temperature ranges for particular components of the sandmix.

Results of approximation of dimensional change of blocks in cooling phase, are presented in table 1.

Many functions were used for experimental data approximation. After numerous trials those which allowed the best fitting were chosen. Above data are the base for elaboration of suitable computer programs.

Table 1.
Results of approximation of dimensional change of blocks in cooling phase

Lp	Plaster/Silica %	Temperature range °C	Polynominal factor	Square of correlation coefficient R^2
1	100/0	99,6÷802,43	Stage 0: -4,01243 Stage 1: -0,000281502 Stage 2: 2,48914E-006	0,999317
2	70/30	99,79÷655,36	Stage 0: -1,80086 Stage 1: 0,000793243 Stage 2: -1,21456E-0,006 Stage 3: 4,00691E-009	0,998957
3	70/30	655,36÷800,97	Stage 0: -1,09928 Stage 1: -0,000265307 Stage 2: 1,37398E-006	0,999426
4	60/40	101,00÷611,56	Stage 0: -1,5432 Stage 1: 0,000487235 Stage 2: -7,17829E-007 Stage 3: 3,9230E-009	0,998193
5	60/40	611,56÷801,63	Stage 0: -19,7992 Stage 1: 0,0774738 Stage 2: -0,000104629 Stage 3: 4,79609E-008	0,998774
6	50/50	100,09÷661,43	Stage 0: -1,18682 Stage 1: 0,00106838 Stage 2: -2,42824E-006 Stage 3: 5,39636E-009	0,998453
7	50/50	661,43÷800,75	Stage 0: -0,337467 Stage 1: -0,000201761 Stage 2: 1,03788E-006	0,999489
8	40/60	99,84÷646,79	Stage 0: -1,09678 Stage 1: 0,00179944 Stage 2: -4,72855E-006 Stage 3: 7,7428E-009	0,997053
9	40/60	646,79÷800,55	Stage 0: 0,100811 Stage 1: -0,000631196 Stage 2: 1,1069E-006	0,999153
10	30/70	100,74÷622,00	Stage 0: -0,771956 Stage 1: 0,00155437 Stage 2: -3,63483E-006 Stage 3: 6,43884E-009	0,997708
11	30/70	622,00÷800,16	Stage 0: -25,0834 Stage 1: 0,103572 Stage 2: -0,000140312 Stage 3: 6,37131E-008	0,996157
12	0/100(98)	100,64÷622,47	Stage 0: 0,0389928 Stage 1: -0,00624164 Stage 2: 4,10124E-005 Stage 3: -9,26063E-008 Stage 4: 7,80694E-011	0,997738
13	0/100(98)	622,47÷800,00	Stage 0: 1,44197 Stage 1: -9,35938E-005	0,812482

3. Elaboration of computer program to calculate dimensional changes of the moulds made of various compositions, during cooling process

Presented programs give answers for following problems:

KOMCJA51

I - Calculate dimensional change of the mould made of particular plaster composition in specific casting temperature:

Given: TzalF=***, SiO2zad=****
Find : DLzadF=?

KOMCJA6

II – For given quantity of relative dimensional change of the mould DL find mould temperature TzalF and composition of different mixtures (SiO_2 to plaster ratio - HF) allow obtaining predetermined value
Given: DLzad=***
Find: TzalF=?, HFzad=?,

Examples of calculation results at given temperature and composition of the mould ready for casting, to find its dimensional changes under such conditions.

Calculated with use of "KOMCJA51" 04-12-2008
******Program relates to composition: HF/SiO2.******
Temperature of the mould TzalF = 100 – 800°C
For composition SiO2=0-98 %
TzalF= 328.2 °C
Compostioni – SiO_2 percentage, %
SiO2zad= 27.56 %
DLzadp= -1.717 %

Calculate for next data: Y/N

Second example relates to situation in which dimensional change is given and the chemical composition and mould temperature are to be found.

Calculated with use of "KOMCJA51" 04-12-2008
******Program relates to composition: HF/SiO2.******

Mould temperature TzalF = 100 – 800 °C for composition SiO2 = 0-98 %
DlzadF= -0.4

1. ***FOR SiO2 = 0.00 % CORRESPONDING CONTRACTION EQUALS:***
   MIN CONTRACTION DL00100p = -4.0157 %
   (dimensional change for TzalF = 100 st.C)
   MAX CONTRACTION DL00800p = -2.6446 %
   (dimensional change for TzalF = 800 st.C)
2. ***DLA KOMPOZYCJI SiO2 = 30.00 % CORRESPONDING CONTRACTION EQUALS:***
   MIN CONTRACTION DL30100p = -1.7297 %
   MAX CONTRACTION DL30800p = -0.4322 %
3. ***DLA KOMPOZYCJI SiO2 = 40.00 % CORRESPONDING CONTRACTION EQUALS:***
   MIN CONTRACTION DL40100p = -1.4977 %
   MAX CONTRACTION DL40800p = -0.2267 %
   For given contraction "DLzadF" temp.of mould: TzalF = 690.40 st.C
4. ***DLA KOMPOZYCJI SiO2 = 50.00 % CORRESPONDING CONTRACTION EQUALS:***
   MIN CONTRACTION DL50100p = -1.0989 %
   MAX CONTRACTION DL50800p = 0.1654 %
   For given contraction "DLzadF temp.of mould: TzalF = 560.80 st.C
5. ***DLA KOMPOZYCJI SiO2 = 60.00 % CORRESPONDING CONTRACTION EQUALS:***
   MIN CONTRACTION DL60100p = -0.9564 %
   MAX CONTRACTION DL60800p = 0.3043 %
   For given contraction "DLzadF" temp.of mould: TzalF = 504.00 st.C
6. ***DLA KOMPOZYCJI SiO2 = 70.00 % CORRESPONDING CONTRACTION EQUALS:***
   MIN CONTRACTION DL70100p = -0.6464 %
   MAX CONTRACTION DL70800p = 0.3043 %
   For given contraction "DLzadF" temp.of mould: TzalF = 348.00 st.C

Calculate for next data: Y/N

For given dimensional change DLzadF = -0,4% program calculates and presents chemical composition of the mixture that does not fulfill requirements (point. 1 and 2).

Next, program calculates and presents chemical composition of the mixtures fulfilling condition DLzadF = -0,4% giving required for them temperature for mould ready for casting (point. 3, 4, 5 and 6).

4. 3D graphical representation of dimensional changes of the mould made of various compositions

The 3D plot was created on the base of carried out calculations. The plot represents relative dimensional changes of the mould DL in the dependence on mineralogical composition of the mould as well as its temperature at the moment of casting.

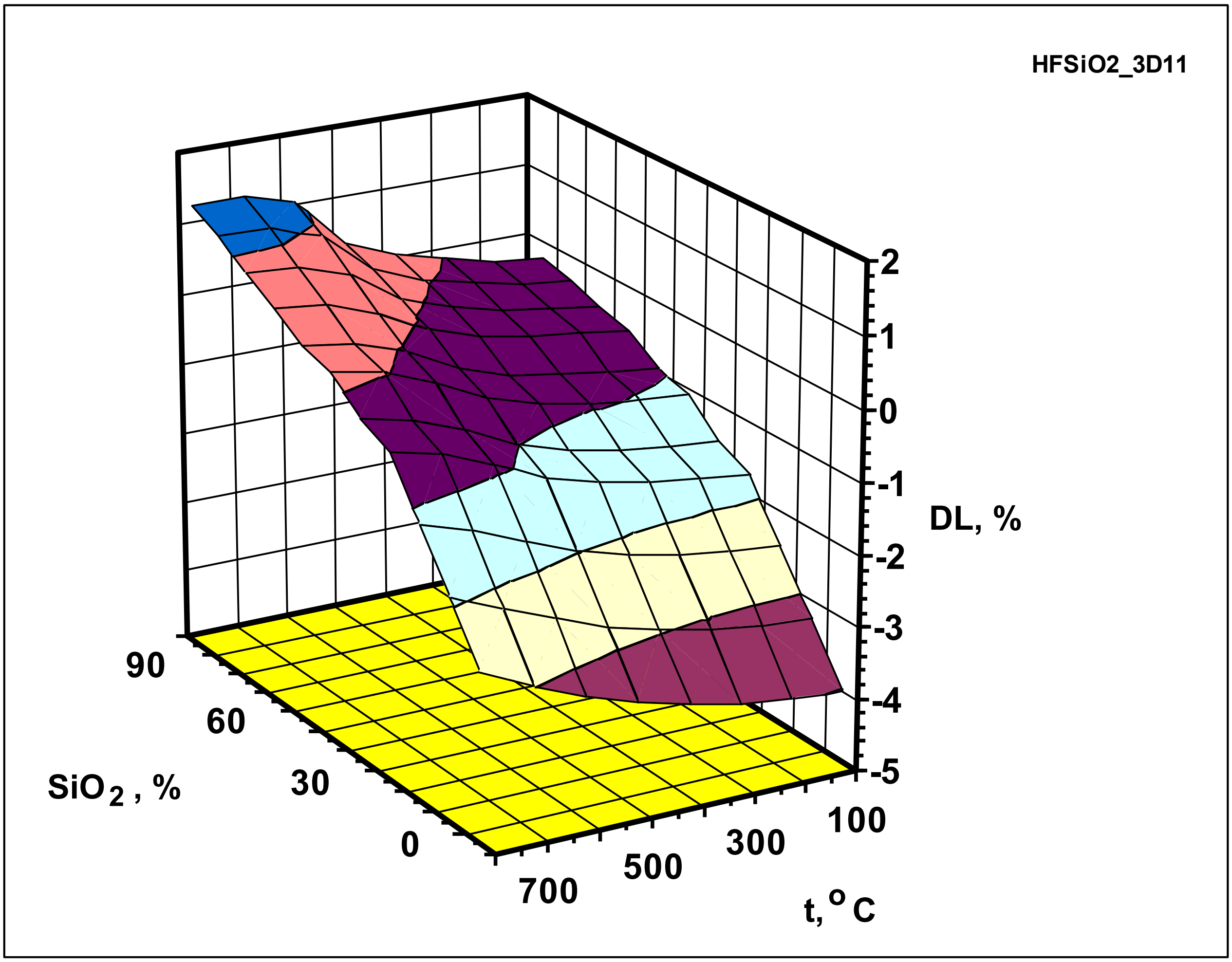

Fig. 2. Relative dimensional change DL in function of temperature and various content of SiO_2 in the range 100-700°C

The analysis of the dependence **DL(TzalF, SiO2)** allows easy evaluation of the influence of particular quantities on dimensional changes of the mould, as well as intensity of the change and its character. Previously presented computer software allow to calculate dimensional changes and selection of chemical composition more accurately.

5. Final remark

Elaborated computer programs allow calculations of forecasted dimensional changes of the mould prepared of known composition or determination required temperature and chemical composition of the mould at which mould assures obtaining cast of precise dimensions.

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