ARCHIVES of FOUNDRY ENGINEERING

ISSN (1897-3310)
Volume 10
Issue 2/2010

95 – 98

18/2

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

# The influence of the conditions of gypsum plaster preparation on its technological properties

**M. Pawlak***
Department of Materials Technologies and Production Systems, Technical University of Lodz,
1/15 Stefanowskiego Str, 90-924 Łódź, Poland
*Corresponding author. E-mail address: marek.pawlak@p.lodz.pl

Received 30.04.2010; accepted in revised form 10.05.2010

## Abstract

The results of researches on influence of basic preparation parameters, i.e. time and mixing intensity, start and end time of set, dimensional changes and strength of gypsum plaster, are presented in this paper. Determination of mentioned above parameters has a significant meaning because of their influence on quality of gypsum plaster and its susceptibility to even small disturbances during preparation. Tested plaster was prepared in vacuum mixer St. LOUIS 82. Time of mixing was 60÷360 sec., mixer arm rates 150÷420 rpm. It was demonstrated that mixing time influences strongly the setting time and expansion of gypsum plaster , and this influence growths with growing mixing intensity. The intense, short time mixing is beneficial from the viewpoint of dimensional changes minimizing. Minimizing the setting time is the most beneficial at low mixing intensity but significant dimensional changes appear during setting the plaster.

**Keywords:** Modern Casting Materials and Technologies, Precision Casting, Gypsum Mould, Technological Properties of Gypsum Plaster

## 1. Introduction

The gypsum moulds applied in precision casting allow to obtain casts of good dimensional accuracy, very good shape representation and low surface roughness. However it is a technology very sensitive, to even small disturbances in preparation procedure of both plaster and mould. These modifications influence mainly the dimensional accuracy of the casts. The significant parameters for plaster and mould preparation technology are: setting time, dimensional changes and strength . The setting time and precisely the start of time of this process decides about its usability for moulding and the possibility of its controlling what influences the time and economy of mould preparation. The dimensional change of the plaster is very important for dimensional accuracy of the mould. The strength of the plaster is important in the context of heat treatment which can lower this value even few times. Mentioned above parameters are strongly dependent on plaster preparation conditions - the time and intensity of mixing.

Currently in the Department of Materials Technologies and Production Systems of Technical University of Lodz studies on the technology of plaster mould and plaster-bonded investment casting using of vacuum are conducted within the frame of Research Project No. N N508 3886 33 financed by Polish Ministry of Science and Higher Education [3÷8].

# 2. Scope and methodology of researches

The goal of the researches was to determine the influence of gypsum plaster preparation conditions on:

- setting time $t_w$,
- dimensional changes w,
- bending strength in set condition $R_g^u$.

The vacuum mixer St LOUIS 82 B/P provided by CIMO S.R.L. equipped with frame mixing arm of rates range 150÷420 rpm was used for plaster preparation.

## 2.1. Scope of researches

On the base of preliminary tests and standard recommendation following range of parameters was selected:

- mixing time: 60, 210, 360 seconds,
- rates of mixing arm: 150, 285 and 420 rpm.

Following parameters were determined:

- start and end setting time $t_{wp}$ and $t_{wk}$,
- dimensional changes of set plaster during 24 h,
- bending strength in set state $R_g^u$ after 24 h.

## 2.2. Materials

a) jewellery plaster-bonded investment powder Gold Star XL made by Hoben of following parameters (determined in accordance with standard PN-86/B-04360):

– powder-water ratio for flow ø 120 mm: W/G=0,40

– setting time: start: $t_{wp}$=16'30'' end: $t_{wk}$=18'00''

– bending strength after 2h: $Rg^u$=1,2 MPa,

b) distilled water

## 2.3. Metodology

**A. Material preparation**

Gypsum powder Gold Star XL was used in delivered state. It was stored in hermetically closed containers due to its susceptibility to moisture.

**B. Gypsum plaster and experimental forms preparation**

The plaster was prepared in vacuum mixer St. LOUIS 82 (Fig. 1) in following procedure [9, 10]:

– pouring of weighted dry powder into the mixer chamber,
– degassing under vacuum during 120 sec,
– mixing the slurry under vacuum,
– adding measured amount of distilled water,
– pouring the slurry into the laboratory ware (in the vacuum casting moulds chamber).

Ready mix of consistency of thick cream was poured into experimental form uniformly on whole surface. Then, the form was shake 10 times to remove air holes. After first signs of setting the liquid mix - the matting of the surface, after 3 minutes, the excess of the plaster was removed and the surface smoothen by steel plate.

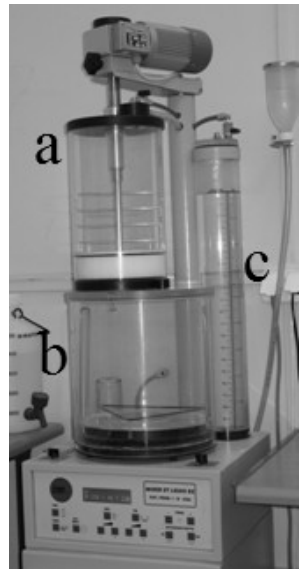


Fig. 1. Vacuum mixer St. LOUIS 82 B/P: a – vacuum chamber with frame mixing arm , b – casting moulds chamber, c- distilled water feeder

**C. Determination of setting time $t_w$**

Tests were made in accordance with procedure given in standard PN-66/B-04360 with use of Vicat apparatus of moving parts weight 300±2 g (Fig. 2). The steel needle of dimension Ø1±0,02 mm and measurement ring of height 40±0,5 mm were used. The ring was fulfilled with gypsum plaster. The time after which needle immersed in liquid mix stopped at 2 mm distance from steel plate being the base of the ring was assumed as a start of setting time. The depth of needle penetration time at distance no longer then 1 mm was assumed to be the end of the setting process. The time of start and end of setting was measured from the moment of water addition to the dry gypsum composition.

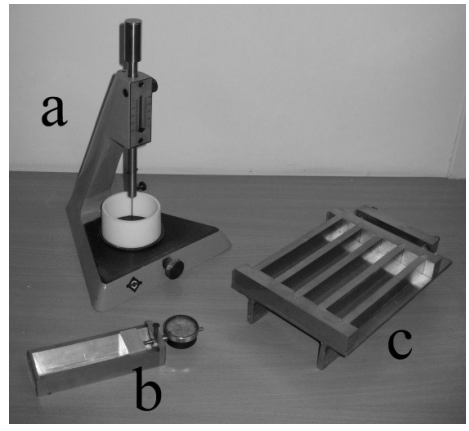


Fig. 2. Test stand for determination of technological properties of gypsum plaster: a – Vicat apparatus with measuring ring, b – form for linear dimensional changes determination of set plaster, c – experimental shape for lengthwise samples

**D. Determination of linear dimension changes of set plaster, w**

The test was carried out with use of form in triangular shape 25x25 mm and length 100 mm (Fig. 2). The form was fulfilled with gypsum plaster and prepared to test in accordance to procedure explained in point 2.3B. The value of dimensional changes of set sample was read from the dial indicator after period of 15, 20, 25, 30, 60, 120, 240, 480 and 1440 minutes from the moment of adding water to dry gypsum composition.

**E. Determination of bending strength of set gypsum plaster, $R_g^u$**

The typical lengthwise shapes were used in this test elaborated for bending strength test of moulding plaster in set state, $R_g^u$, of dimensions 22,36x22,36x172 mm (standard PN-83/H-11070). They were prepared in four-cavity experimental mould (Fig. 2) in accordance to procedure described in 2.3B. The bending strength was measured in raw state (after 2 h from mixing the sand with water) with use of LRu apparatus.

# 3. Results

## 3.1. Setting time $t_w$

The results of researches are presented in Figure 3. The conclusion is that the decisive influence on the time to set value has the mixing time $t_m$. The more intense mixing cause the more legible effect. At minimum mixing intensity (n=150 rpm) the difference $t_{wk}$ for $t_m$=60 sec and $t_m$=360sec is ~5%. At maximum mixing intensity (n=420 rpm) the $t_{wk}$ is ~26%. Thus, from the technological point of view less intense mixing should be better, however the dimensional change increases disadvantageously (Fig. 4).

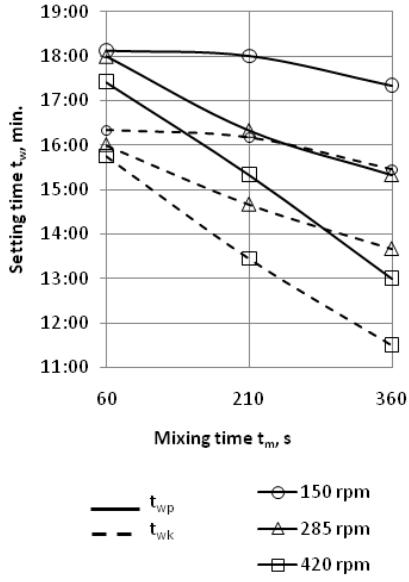


Fig. 3. The dependence between setting time of gypsum plaster $t_w$ and mixing time $t_m$

The intensity and duration of mixing affect strongly the setting time of plaster what is connected with gypsum specific setting. This process starts at the moment of water addition. Mixing disturbs it by destroying acicular structures. The refined structure sets more easily and faster.

## 3.2. Relative linear dimensional change of set plaster w

The analysis of experimental results showed that after 120 minutes, the dimensional changes of the mould are negligible.

Results of test are presented in Figure 4. On this base it can be stated that modification in mixing time has a significant effect on the dimensional change of set plaster, especially at low mixing intensity (for n=150 rpm the difference between $t_m$=60 sec and $t_m$=360 sec is ~46%).

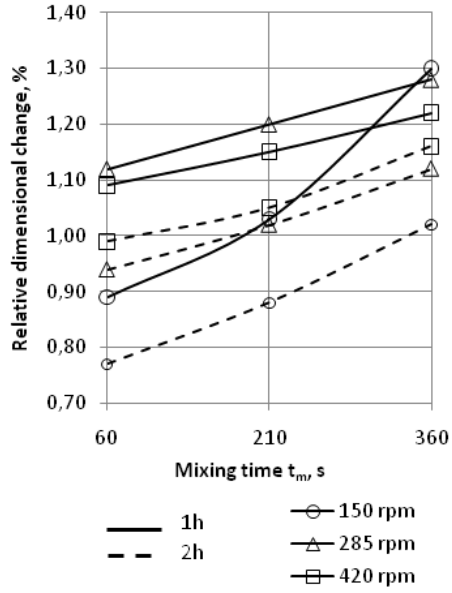


Fig. 4. The dependence between relative dimensional change of set gypsum plaster and mixing time $t_m$

In case of intense mixing (n=420 rpm) this difference is significantly smaller and is ~12%. Such a sharply outlined dependence between dimensional changes and mixing intensity is a result of specific gypsum setting phenomena. Mixing upsets the equilibrium processes by destroying created crystals. Refined structure has higher density and thus lower expansion.

## 3.3. Set state bending strength $R_g^u$

The results of test are presented in Figure 5. The modification of mixing time distinctly affects the strength of gypsum plaster (determined after 2 h). However this effect is not unequivocal: at intense mixing the strength of the plaster decreases with increased mixing time, at low mixing intensity increases with mixing time.

This dependence can be explained, as in case of time to set and dimensional changes, by specific gypsum setting process. The

structure of mixed plaster undergoes long and intense refinement what causes its density decreases and thus the strength. At "smooth" mode of mixing, the structure is destroyed only a little, and long period of this stage improves the setting conditions therefore increases the strength after setting.

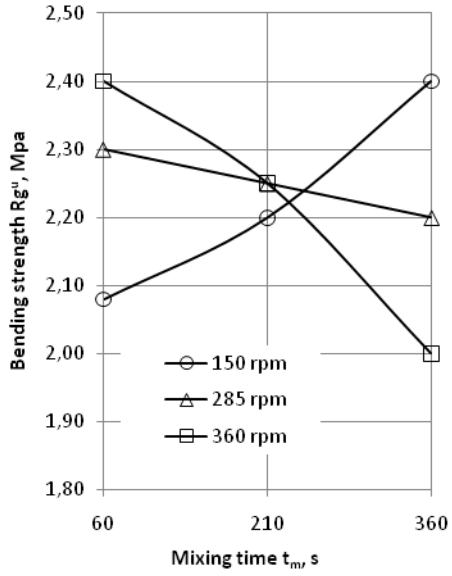


Fig. 5. The dependence between the bending strength of set plaster $R_g^u$ and mixing time $t_m$

# 4. Conclusions

The analysis of researches results allows to formulate following statements.

1. The time and intensity of mixing strongly affect the basic properties of gypsum plaster – setting time and relative dimensional change as well as the strength.
2. The increase of mixing time at its low intensity causes slight shortening of the setting time, slight strength increase and significant increment in relative dimensional change of the plaster.
3. The increase of mixing time at its high intensity causes very large decrement in setting time, decrement in strength and slight increase of relative dimensional change of set plaster.
4. Intense mixing during short time allows obtaining the most advantageous technological properties of the tested gypsum plaster.

# Acknowledgements

The work was made as a part of a research project No. N N508 3886 33 financed by founds for science in the years 2007-2010 by Polish Ministry of Science and Higher Education.

# References

[1] Lewandowski L.: Moulding Materials. AKAPIT, Warszawa 1997 (in Polish)
[2] Nelson C.D.: Plaster Molding, Metal Handbook, Vol. 15, Casting, (1988), s. 242÷247
[3] Pawlak M., Niedźwiedzki Z.: Computer aided process of dimensional distortion determination of bounded plaster plaster, Part II. Archives of Foundry Enginerring, Vol. 10, Issue 1, January – March 2010, p. 105÷108
[4] Pawlak M., Niedźwiedzki Z.: Computer aided process of dimensional distortion determination of bounded plaster plaster. Archives of Foundry Engineering, Vol. 9, Issue 3, July – September 2009, p. 261÷266
[5] Pawlak M., Niedźwiedzki Z.: Dilatometric studies of plaster plaster in raw and heat treated state. Archives of Foundry Engineering, Vol. 8, Issue 3, July – September 2008, p. 145÷148
[6] Pawlak M.: Influence of temperature and time of firing on the properties of gypsum. Polska Metalurgia w latach 2002-2006, Komitet Metalurgii Polskiej Akademii Nauk, Kraków 2006 (in Polish)
[7] Pawlak M.: The firing gypsum mould for artistic casting. Archiwum Odlewnictwa, PAN, 2006, Nr 19, s. 213÷220 (in Polish)
[8] Pawlak M.: The preliminary baking gypsum moulds for artistic casting. Archiwum Odlewnictwa, PAN, 2005, Nr 17, s. 225÷232 (in Polish)
[9] Service manual of mixer St. LOUIS 82 B/P by CIMO S.R.L.
[10] Folder of Hoben International Ltd., 2007
[11] PN-86/B-04360 Spoiwa gipsowe. Metody badań. Oznaczanie cech fizycznych