Diyala Journal of Engineering Sciences

ISSN 1999-8716

Printed in Iraq

Vol. 05, No. 02, pp. 129-136, December 2012

IMPROVEMENT OF WORKABILITY OF PORCELAIN UNDER EFFECT OF ALUMINA

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(Received:25/2/2012 ; Accepted:18/3/2012)

ABSTRACT:- Adding of alumina to porcelain improve the mechanical properties of the green and fired body.

This improvement depend on the properties of the added alumina, such as surface area, morphology and the percentage of the alumina.

Adding of alumina effected also the properties of porcelain slip viscosity , less grinding of alumina result in high slip viscosity.

The increasing of grinding finesse of the alumina rise the rate of body formation.

This investigation showed that the alkali content of the alumina and the crushing states have significant effects on the workability of the porcelain green body.

Keywords:- Alumina, mechanical properties ,surface area, morphology, viscosity, porcelain workability.

1. INTRODUCTION

The properties of porcelains depended both on the body composition and on the conditions of manufacture.

This research deals with effects of various alumina on the workability and properties of the fired body.

2-EXPERIMENTAL PROCEDURE

The subject of investigation was an industrial-grade porcelain body made of feldspar, kaolin and quartz in such proportions that adding a suitable amount of alumina would yield a following composition:

30% alumina

45% kaolin

17%quartz

8% feldspar

Two types of alumina were selected for use in the experiments.

Type –CT 999 alumina is calcined to such an extent, that the primary crystals take on a plate –like habit. Type-CT S alumina is less heavily calcined , so that the particles still have a round habit.

The aluminas were ground to various degree of fineness:

Designation	Max. Grain size (µm)
G (ground)	63
FG (fine ground)	45
SG (super ground)	20

Table(1) lists several of the aluminas properties and correlates them to the individual composition numbers.

The specimens were obtained by casting inorder to avoid falsifying the effects of the alkali contents of the aluminas on the properties of the slips , no deflocculants were used. firing was conducted by way of analogy to production conditions at SK 9 (laboratory PCE corresponding to approximately 1315 $^{\circ}$C).Many trails done before showed that firing temperature to be optimal.

The following properties were investigated:

- viscosity of slip , as measured in a rotational viscosimeter. -body formation
- bulk density , both green and fired, determined according to the mercury buoyancy method
- dry bending strength

- 3-point bending strength of fired specimens.

3- RESULTS

The results of investigation.The rheological properties of slips andwater absorption as a function of time are depicted in figures 1 and 2respectively.Tables 2 through 4 list the results of density measurements and strength testing.

The solids contents stated for the suspensions refer to the total mass of the suspension.

4- DISCUSSION OF RESULTS

4.1 casting –slip viscosity curves

Figure 1shows the different deflocculants of the suspensions of the bodies No.1-5.

According to Teuchert (1) this typical Characteristic of incompletely deflocculated slip .

Grinding the alumina proved to yield a significant reduction in the yield value (curves 1,2 and figure1) for which there are two main reasons : On the hand , kunz(2) calls attention to the effects of particle shape on the viscosity of suspensions , i.e. elliptical particles yield higher viscosity than round particles in a slip with a given concentration. Grinding , however , rounds off the alumina particles on the other hand higher specific surface area of ground alumina allows more rapid entry of soluble alkalies into the suspension , with the effect that additional deflocculation can occur during measurement of the viscosity .

Body No .5, the one containing the superfine alumina CT S GS . constitutes an exception to the rule ,for which ,again, two reasons can be stated: on the one hand , this type of alumina has a significantly lower alkali content -both total and soluble – meaning that less secondary deflocculation can be expected. On the other hand , the slip in question has a somewhat higher solids content , which , of course leads to higher viscosity for given shear – stress level .i.e. to a higher yield value Investigations concerning the effects of solid content on slip viscosity have shown that slip react very sensitively to changes in concentration .

Blasius, Wagner and Wiechmann(3) detected a similar reaction of ceramic slips to slight changes in solids content .

Our studies also showed that the less the alumina fineness, the quicker the slip viscosity will increase in reaction to a rise in the solids content This corroborates the notion that the reheological situation is governed by the more or less rapid transfer of soluble alkali out of the alumina and into the suspending agent , with the rate of transfer , in turn, depending on the specific surface area.

4.2 Body formation

As the grinding fineness of the alumina increases , the rate of body formation also rises , as indicated by the amount of water absorbed by the mold (fig.2)

Phase separation observed in diluted slips was found to intensify as a function of the coarseness of the alumina.

The grinding fineness of the alumina is seen to affect the green density (table 2) this is not surprising , since brief grinding leaves a wider particle –size spectrum in the overall composition. At the same time , however , it also exerts an influence on firing shrinkage such that the effect is reversed when the specimens are fired.

The finer alumina CT S produces a generally looser body and a somewhat higher rate of firing shrinkage.

4.3 dry strength

4.3.1 Effects of alumina fineness

All data shown in table 3 confirm that the dry bending strength increases along with the grinding fineness of the alumina.

4.3.2 Comparison of aluminas

The established property values show that , for aluminas of comparable grinding fineness and comparable specimen preparation procedures , the bodies containing type –CT 999 alumina developed a higher dry bending strength than did those containing type –CT S alumina. This could be at least partially attributable to the comparatively high alkali content of type CT 999 alumina , which causes a certain degree of slip deflocculation and, hence, a denser body (as indicated by the table -2 data) ,which , in turn, has a favorable effect on dry strength.

The observed effects of aluminas with higher alkali contents are in agreement with data gathered by Teuchert (1) on the effects of deflocculation on body density.

4.4 strength of fired specimens.

4.4.1 Effect of Alumina fineness.

Like the strength the bending strength of fired specimens increases along with the grinding fineness of alumina (table 4) .This observation is in accordance with earlier results obtained by Schuller and Koch (4).

4.4.2 Comparisons of aluminas

The results show that batches prepared with type –CT 999 alumina yield specimens with higher bending strength than those containing type –CT S alumina. The strength values reflect differences in the degree of body compaction occurring during firing . These result differ from those obtained by Schuller and Koch (4). who found that , for optimal firing conditions , the strength of fired specimens made with aluminas of different primary crystal size dose not vary a great deal. Is should be noted , however , that the alkali containtes of the alumina in question differed widely . In the case at hand , for example , the lower –calcined alumina also had the lower alkali content , while the finer alumina used by Schuller and Koch (4)had a substantially higher alkali content. Considering the obvious effect of alkalies on body workability as documented in the preceding sections, the extent to which this dose or dose not affect the strength of the fired body remains an open question .

Results obtained by Thaler and Schuller (5),Mostetzky (6),and Mortel (7) using washed aluminas speak in favor of the existence of such causalities , since they also showed lower fired –body strength levels for lower alkali contents.

5- SUMMARY

The investigation showed that the aluminas , their alkali contents and their fineness have significant effects on the workability of the respective bodies and on the properties of those bodies, both in the unfired and fired state. Adequately intensive grinding of the alumina is always advisable. Nonetheless ,however, body compaction due to shaping also has an effect on strength to the extent that optimal defoccation (here intentionally disregarded)can modify the results. These results indicate that the use of low alkali aluminas in porcelain bodies is of no particular advantage.

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Table (1): Characteristic values determined for the various alumina (incl.body numbers).

Alumina:	CT 999 G	CT 999 FG	CT 999 SG	CT S FG	CT S SG
Body number	١	٢	٣	٤	٥
Na_2O Content total Water soluble	0.32% 0.19%	0.34% 0.16%	0.34% 0.12%	0.22% 0.10%	0.20% 0.08%
Alum.spec. Surface area BET g/m^2	0.34	0.85	0.85	1.18	1.27
D_{50} value in µm	13.7	6.6	5.6	4.4	4.4

Table (2): Green density bulk density and firing shrinkage of cast specimens containing 52% solids at the time of casting.

Body	Green density in g/cm^3	Bulk density (fired at SK 9) in g/cm^3	firing shrinkage in %
1	1.70	2.66	12.2
2	1.67	2.67	12.8
3	1.67	2.69	13.0
5	1.64	2.62	13.2

Table (3): Dry bending strength of cost rods.

Body	Strength in N/m^2	Standard deviation S in N/m^2	Standard deviation relative r in %
1	1.60	0.122	7.7
2	1.76	0.163	٨.٧
3	1.89	0.100	5.3
٤	1.35	0.090	٦.٧
5	1.52	0.089	5.9

Table (4): Strength of fired rods (firing temperature : SK 9).

Body	Strength in N/m^2	Standard deviation S in N/m^2	Standard deviation relative r in %
1	64.62	3.17	4.9
2	76.93	3.21	٤.٢
3	84.42	5.85	6.9
٤	52.44	5.75	١١.٠
5	63.74	3.29	5.2

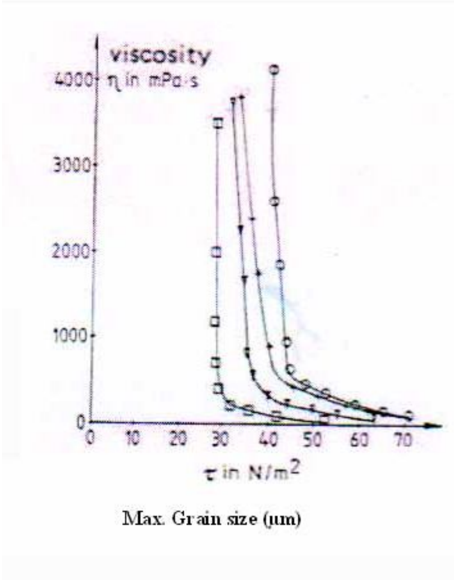

Fig.(1): Viscosifty curves for θ=22 C^0:Bodies 1(+) 2(▽) and 3(□)Solids content:52%: body 5(0):solid content:54%:

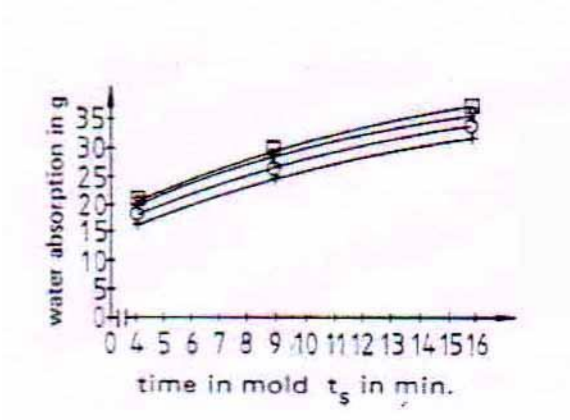

Fig.(2): Water absorption of plaster molds as afunction of time in molds solids content:52%:Bodies,1 (-),2 (▽),3(□), 5(0)

فحص الخواص التشغيلية للبورسلين ذات المحتوى العالي من الالومينا

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الخلاصة:-

إضافة الالومينا إلى البور سلين يحسن من الخواص الميكانيكية للجسم الأخضر(البورسلين قبل الحرق) وكذلك هو الحال للجسم بعد الحرق .

مقدار هذا التحسن يعتمد على خواص الالومينا المضافة مثل المساحة السطحية والأشكال الهندسية لحبيبات الالومينا ونسبتها كمادة مضافة.

كما ان هذه الإضافة تؤثر على خاصية اللزوجة للمحلول فكلما قلت عملية الطحن لحبيبات الالومينا كلما كانت لزوجة المحلول أعلى.

ازدياد نعومة الالومينا تزيد من معدل زيادة سماكة الجدران في عملية الصب للأجسام المتكونة كما إنها تزيد من الكثافة الفعلية لها.

بازدياد نسبة المواد القلوية في الالومينا مع زيادة فترة الطحن لها تتحسن الخواص العملية للإنتاج.

كلمات دالة: الالومينا ، الخواص الميكانيكية، المساحة السطحية ، الاشكال الهندسية ، اللزوجة ،الخواص التشغيلية للبورسلين.