

WBB MINERALS

Casting Slip Control



Working together for mineral solutions



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Introduction

Almost all casting slips used in the production of traditional ceramic 'whitewares' consist of ball clay, china clay, filler and flux in various proportions depending upon the application. The ball clay is the most difficult to disperse and is, therefore, normally processed and allowed to age prior to final casting slip preparation.

The ball clay can be supplied in various forms, including:

- Shredded Blends - require deflocculating and the most processing and aging prior to use
- Noodled - pre-processed, partially deflocculated, easily dispersible with low residue
- Slurried - deflocculated, fully processed and aged ready for use

The other materials are then added to the aged ball clay slurry to form the casting slip with the required properties.

For smaller or more specialised producers, prepared bodies are readily available. Such prepared bodies contain the majority of raw materials necessary for the successful production of most forms of whiteware. The only other raw material requirements may be water and, in factories using the casting process, deflocculants.

The form in which these bodies are supplied varies according to need and may be:

- Deflocculated casting slips with predictable, defined characteristics
- Vacuum extrusions at working moisture contents c. 19-21 %
- "Crumble" - aggregated body at about 10-12 % moisture
- Dry mixed powders
- Noodles

The manufacturer's choice of form will depend on the manufacturing process, the availability of equipment, and the location of the factory.

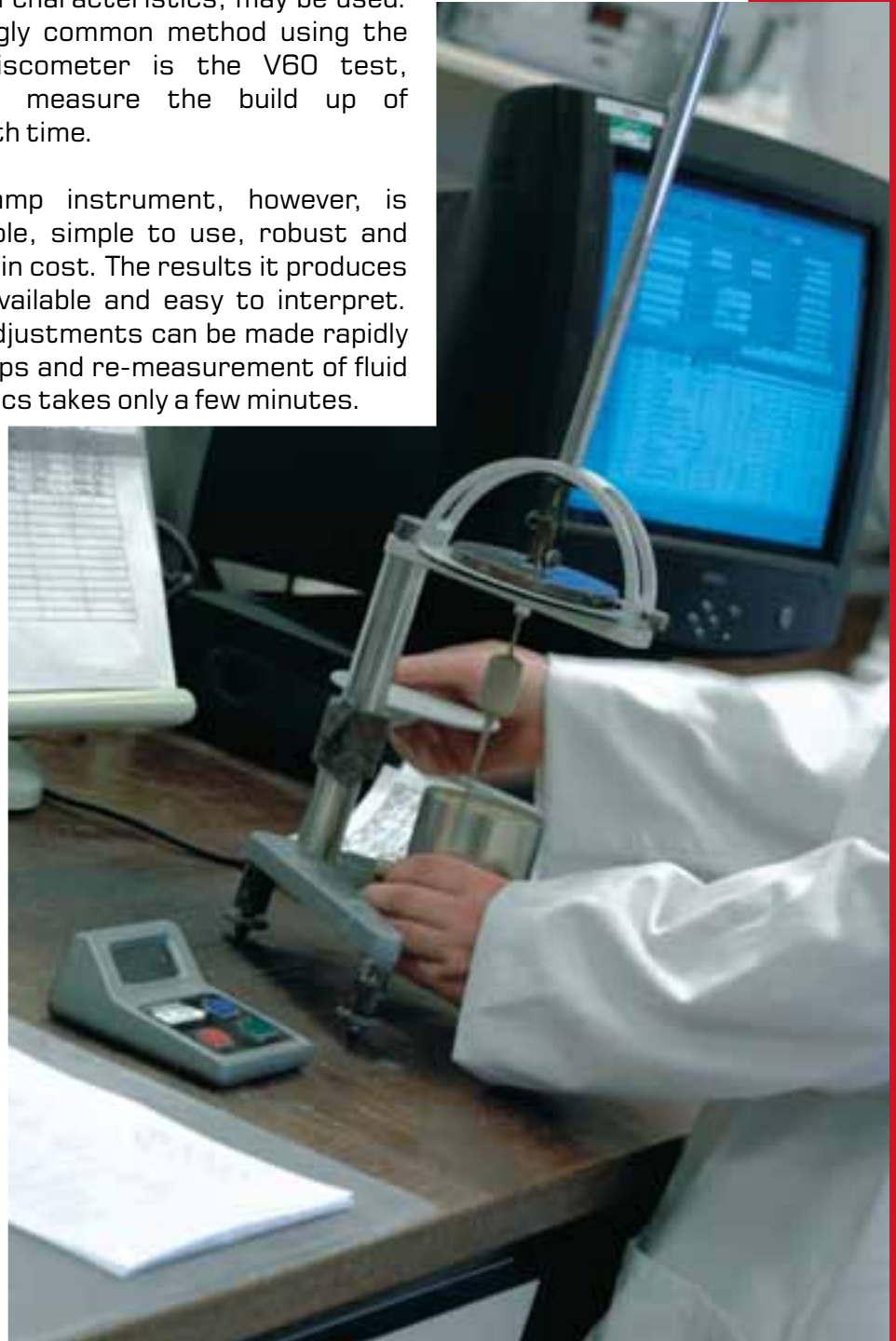
Consistent behaviour of the ball clay and casting slips is vitally important in minimising day to day production problems. Such consistency is essential for the setting of factory production rates which achieve the most efficient and cost effective manufacture of the finished ware.

Slip Control

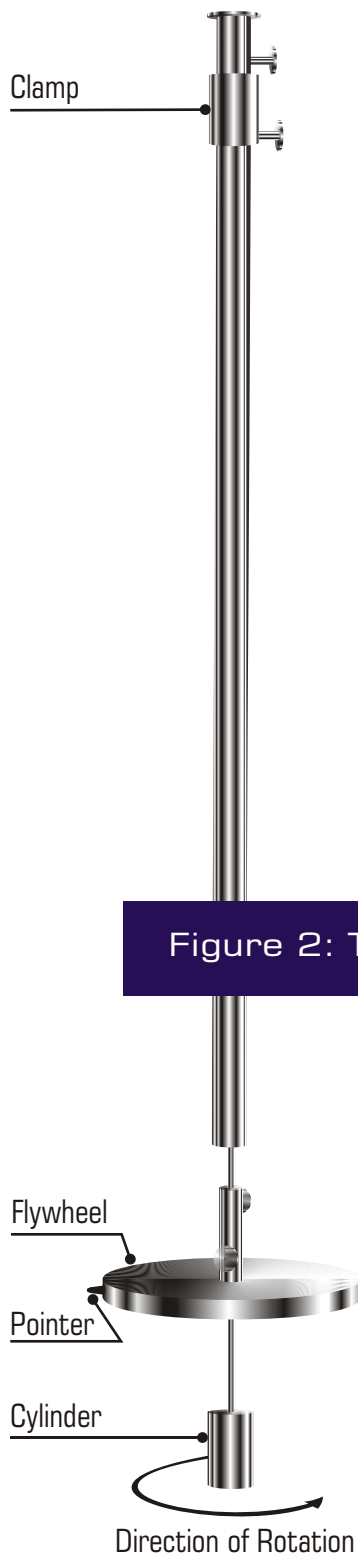
The most widely used method of casting slip control is based on the measurement of fluidity and thixotropy by means of the Gallenkamp Torison Viscometer (GTV or TTV) (figure 1). Other instruments, e.g. the Brookfield Viscometer, or alternative methods, some of which are based on the use of a flow cup to measure fluid characteristics, may be used. An increasingly common method using the Brookfield Viscometer is the V60 test, designed to measure the build up of structure with time.

The Gallenkamp instrument, however, is widely available, simple to use, robust and relatively low in cost. The results it produces are quickly available and easy to interpret. Necessary adjustments can be made rapidly to casting slips and re-measurement of fluid characteristics takes only a few minutes.

Figure 1: Using a Gallenkamp Torsion Viscometer



The Viscometer



The Gallenkamp Viscometer consists of a wire, clamped and suspended from its top end, with a metal cylinder attached to the lower end which is free to rotate with the wire (see Figure 2). When the cylinder is turned through 360° and then allowed to unwind in a container of casting slip, the extent of its rotation is governed by the viscosity of the slip. A flywheel attached to the wire above the cylinder gives a more stable rotation. Hence, the fluidity of the slip can be readily expressed in terms of degrees of rotation.

Several sizes of torsion wire and cylinder are provided with each viscometer. For the control of casting slip, the most common sizes employed are the 30 swg wire and the $1\frac{1}{16}$ " cylinder. Occasionally with certain types of slip, substitution of the $1\frac{1}{16}$ " with the $\frac{1}{4}$ " cylinder will be necessary.

Figure 2: The Gallenkamp Viscometer

Whichever wire size or cylinder is used it is essential to level and adjust the instrument in order that the cylinder can freely rotate. This should be checked by ensuring that after rotation through 360° in either direction, the overswing in air is within 3° of a complete revolution.

Measurement of Fluidity

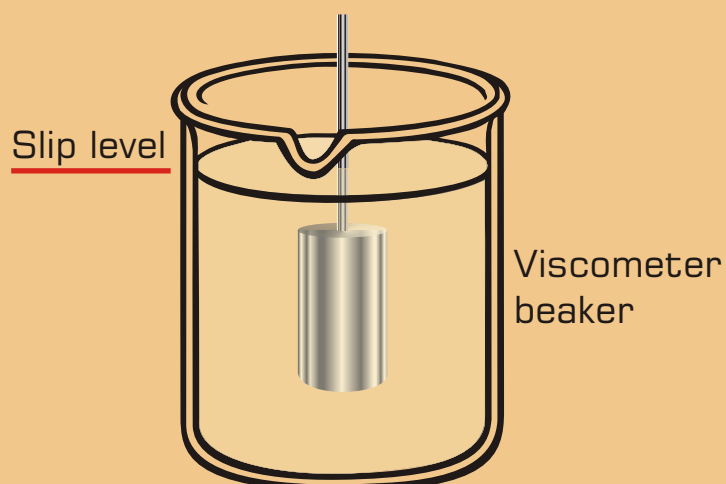
Before taking a measurement of fluidity, the viscometer cylinder must have been wound through 360° in a clockwise direction. With the viscometer beaker in position, the flywheel stop is released thereby enabling the flywheel to rotate in an anticlockwise direction. The overswing indicated by the pointer on the flywheel against the graduated scale is recorded as a measurement of fluidity.

It is important to ensure that the sample of slip is thoroughly stirred immediately prior to the actual measurement.

Samples taken from production blungers or arks should be stirred in the viscometer beaker for exactly one minute, immediately placed into the measuring position and a reading taken after 5 seconds (some allow 15 seconds before taking the reading; either way, it is critical that the time is kept constant to ensure consistent, reproducible results).

It is also important to ensure that the cylinder is fully immersed in the slip being measured (see Figure 3).

Figure 3: Viscometer cylinder fully immersed in slip

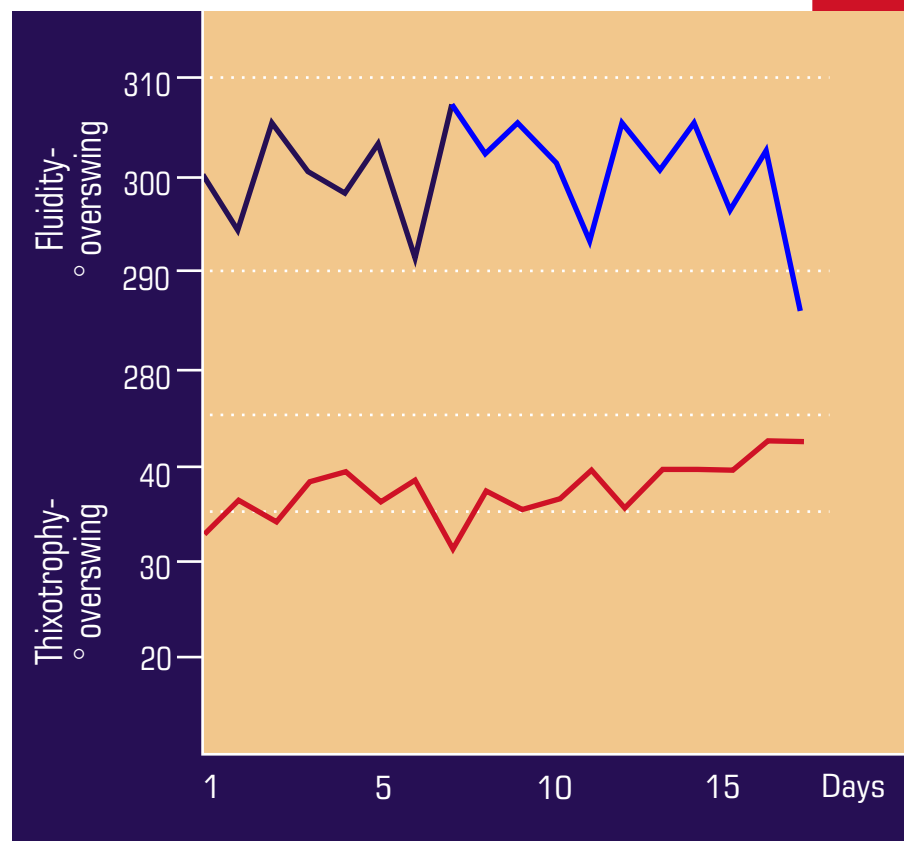


Measurement of Thixotropy

Thixotropy, or the tendency of an undisturbed slip to thicken with time, is an important property which has a marked effect on casting performance. It is measured by rewinding the viscometer flywheel immediately after taking the fluidity reading, allowing the slip to stand undisturbed for either 60 or 90 seconds, and then re-measuring the overswing. Thixotropy is defined as the difference between the two readings. In some instances, a 5-minute thixotropy reading is also useful.

It is important that the temperature of the above measurement is recorded as temperature can severely affect viscosity values.

Figure 4: Typical daily record sheet of fluidity and thixotropy measurements



Measurement of Slip Density

The density of a casting slip must be kept within defined limits as variations will affect casting performance. The use of low density slip can result in the rapid saturation of plaster moulds and subsequent difficulties with second casts and mould drying. Conversely, high density slips can lead to casting and pouring difficulties.

The measurement of slip density is quite simple. A pre-weighed vessel is filled to a calibration mark of either 500 ml or 1 litre and then weighed. The difference in weights represents the weight of a slip in a given volume. Density of casting slip is normally expressed in g/l or g/cm³(equivalent to kg/l).

Figure 5: Measurement of Casting Slip Density



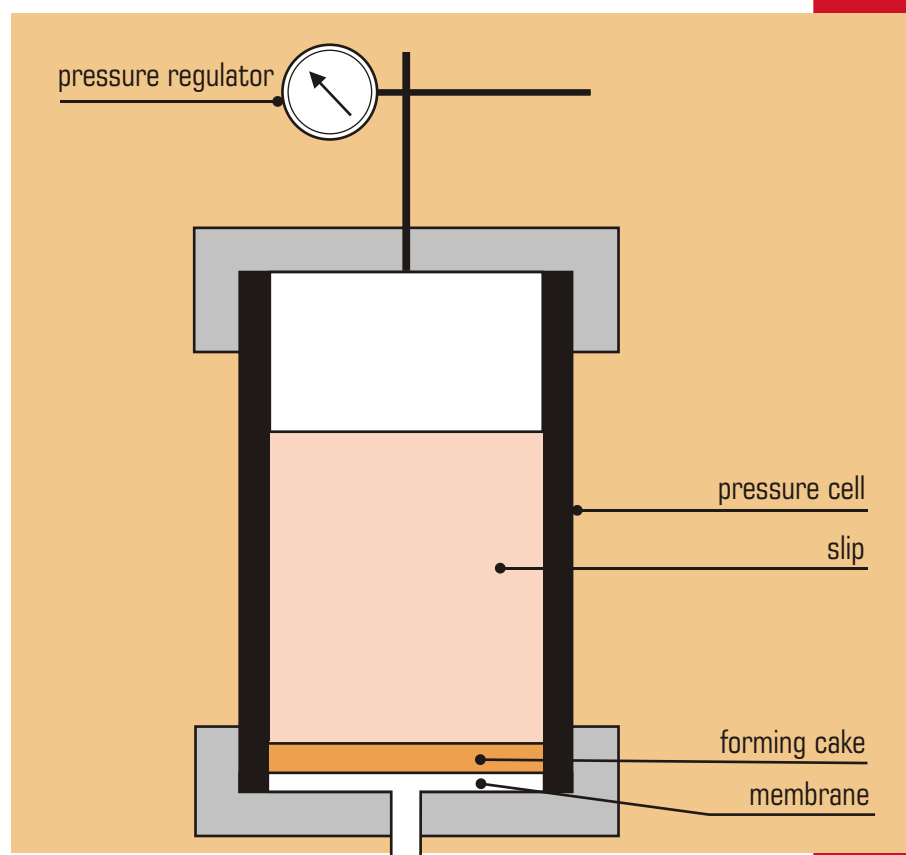
Measurement of Baroid Permeability

The introduction of pressure casting in the traditional ceramics industry has led to the emergence of new testing methods, one of which is Baroid Permeability. Originally developed to provide casting performance data for pressure casting slips, it has also been found useful for quickly comparing the performance of traditional casting slips.

The Baroid Permeability equipment consists of a small pressure vessel with a pressure regulator situated at the top, a filter membrane (normally paper) at the bottom together with an outlet (see Figure 6). The system is filled with slip and then pressurised to a known pressure (usually 75 or 90 p.f.s.i.) for a set time. At the end of the experiment, the filtrate collected is weighed, the slip is drained and the cake produced is either weighed or the thickness measured.

There are several methods of interpreting the results, ranging from reporting the measured cake weight through to carrying out various calculations to achieve a permeability constant for the slip.

Figure 6: Baroid Permeability Equipment



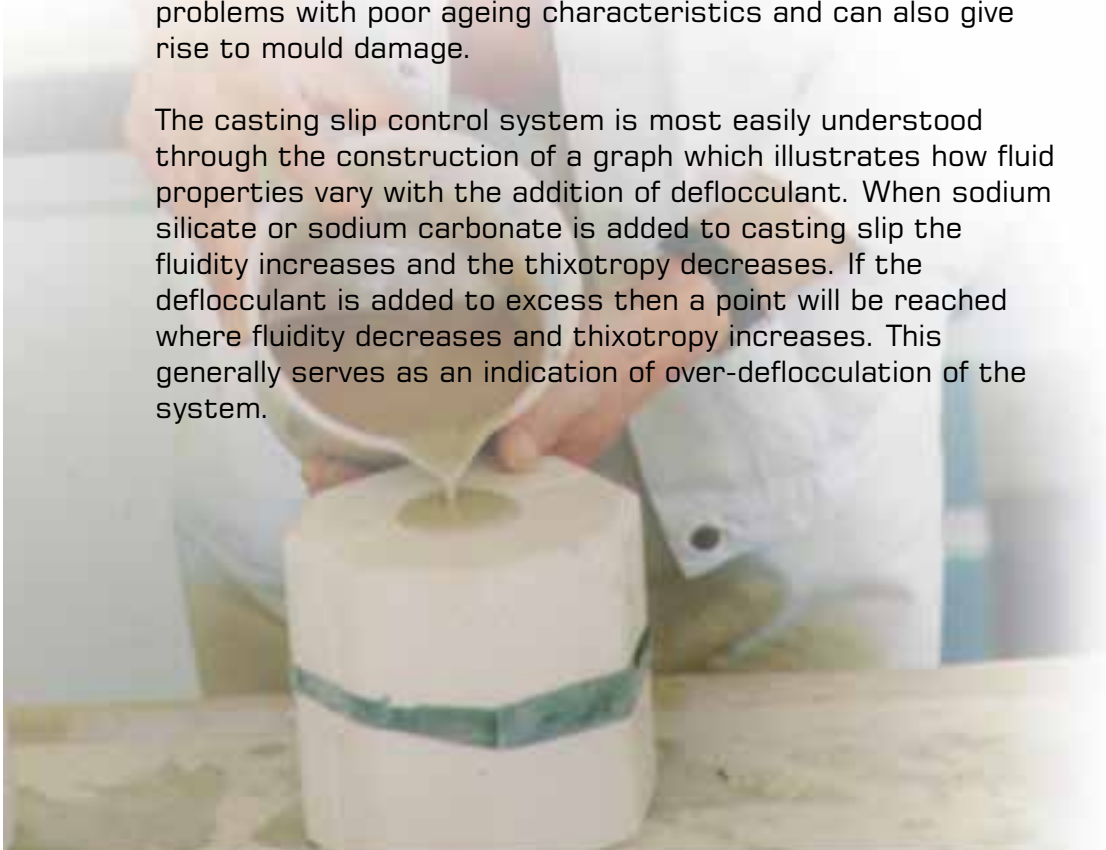
The Control of Casting Slips

It is necessary to specify slip control values which will depend on both the body being used and the type of ware being produced. The best method of arriving at these values is to monitor the fluid properties and density of the slip, and then to compare these observations with casting performance over a period of time. It then becomes possible to relate fluid properties to casting performance. This is extremely important in systems which re-use returned slip and reconstituted scraps mixed with virgin slip.

As a guide, most casting slips perform satisfactorily when set to a fluidity of between 290-310 degrees overswing and a one-minute thixotropy of between 20-50 degrees, at a density of around 1.800 to 1.825 kg/l.

To achieve a fluid casting slip, at suitable solids loading, the clays have to be deflocculated. When possible, it is advisable to use a mixture of sodium silicate and sodium carbonate, as this system is not too difficult to adjust. In some cases when the clays used are particularly difficult to deflocculate, other reagents may be necessary; for example, 'Dispex' a polyacrylate, and 'Doloflux', a mixture of sodium humate and sodium silicate, have proved successful. The use of phosphates should be avoided in ceramic casting slips as these may give problems with poor ageing characteristics and can also give rise to mould damage.

The casting slip control system is most easily understood through the construction of a graph which illustrates how fluid properties vary with the addition of deflocculant. When sodium silicate or sodium carbonate is added to casting slip the fluidity increases and the thixotropy decreases. If the deflocculant is added to excess then a point will be reached where fluidity decreases and thixotropy increases. This generally serves as an indication of over-deflocculation of the system.

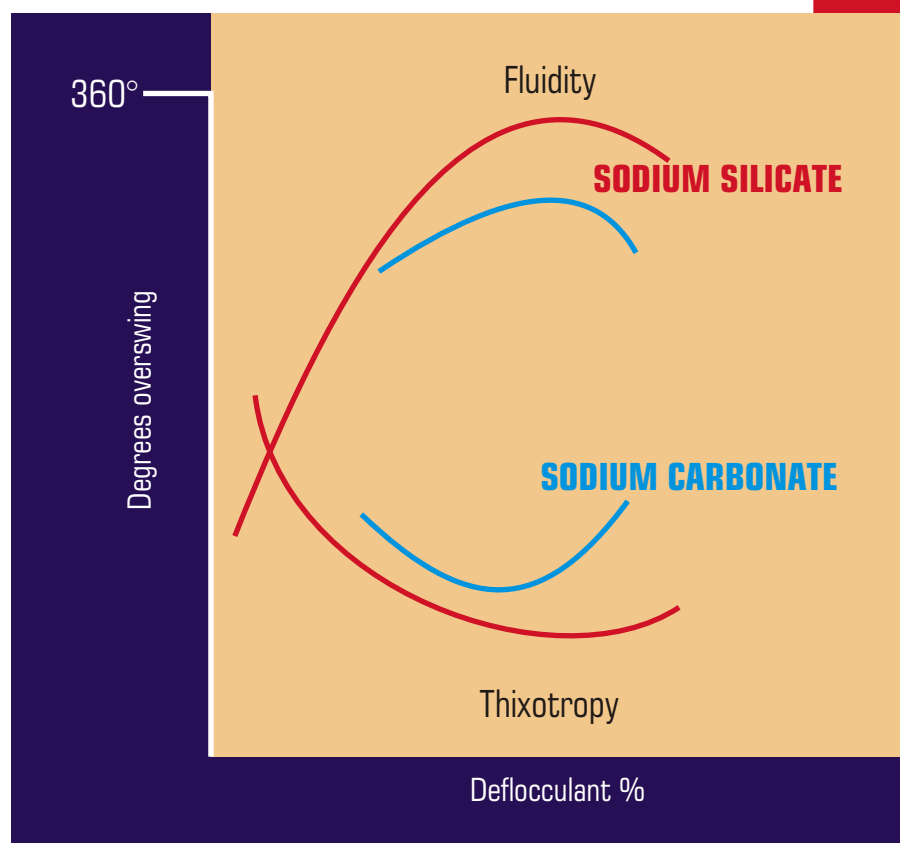


The Control of Casting Slips

Figure 7 illustrates typical deflocculation curves for a casting slip using in one case sodium silicate, and in the other sodium carbonate. Sodium silicate tends to give high fluidity slips with low thixotropy, while sodium carbonate will give lower fluidity slips with higher thixotropy. It is normal practice to use these two reagents together as this offers the possibility of obtaining high fluidity slips with an appropriate degree of thixotropy.

The reagents are mixed in a ratio which will give the most effective control over fluid properties for the given casting slip system. Normally this ratio may vary from 1:1 silicate:carbonate up to 4:1 silicate:carbonate. Processed clays and clay bodies have been developed that include deflocculant in the formulation so that only small additions of sodium silicate are required to the slip prior to casting.

Figure 7: Typical deflocculation curves for casting slip



The Control of Casting Slips

When a silicate/carbonate mixture is used, a progressive addition of deflocculant will increase fluidity to a maximum and further additions will have little effect on the level of fluidity. Thixotropy, however, will decrease steadily as deflocculant is added and will continue to do so even after fluidity has levelled off. In this way thixotropy can be adjusted while fluidity is maintained.

If the maximum value of fluidity is too low, then the density of the slip may be reduced by the addition of water. This will have a marked effect on fluidity, but only a slight effect on thixotropy. The density of the slip will not need to be drastically reduced as a small decrease in density results in a large increase in fluidity. The aim of slip control is to keep the density as high as possible (say 1.800 kg/l) whilst maintaining acceptable fluid properties for effective casting.

The basis for controlling slip to the correct values may be summarised as follows:

1. Measure the fluidity and thixotropy of the slip in the blunger. The density can also be checked at this stage and should ideally lie between 1.800 kg/l and 1.825 kg/l.
2. Add deflocculant to reduce the thixotropy value to about 5 degrees over the required value.
3. Add water to increase the fluidity to the required value. The addition of water at this stage will not have a marked effect on thixotropy, but should bring the fluidity very close to that required.

To allow the correct adjustment of the properties of any slip, it must be initially under-deflocculated and should have a higher density than that finally required. If an over-deflocculated slip requires adjustment then more body will need to be added.

Ageing of Casting Slips

Some casting slips require final adjustment prior to use as their fluid properties change with time. This behaviour is the result of the extremely slow rate of reaction between the various deflocculants and the clay particles in the body system. For example, in the case of earthenware slips, fluidity increases on standing whilst thixotropy will decrease.

The ageing characteristics of a body will vary depending on its make-up. It is usual to age for at least 24 hours in order to obtain stability prior to casting.

It is normal practice for casting returns and clay scraps to be reprocessed and added back into the storage arks. Returned slips and scraps contain sulphate ions absorbed during contact with mould surfaces. If this sulphate is allowed to accumulate in returned and reconstituted slip, it will adversely affect fluid properties and will also be responsible for other faults which may appear later in the production cycle.

The normal method of overcoming the problem of soluble sulphates is to make an addition at the scrap/returns blunger of precipitated barium carbonate. The quantity of barium carbonate required is fairly small as the soluble sulphate levels are also small, probably in the region of 100 to 400 parts per million. The barium carbonate reacts slowly with the soluble sulphate to form barium sulphate which is inert and will not react adversely with the casting slip. Because this is a slow reaction, treated slips should be kept for at least 24 hours prior to use in the casting shop. After storage, fluid properties may be adjusted with deflocculant in the normal way before the slip is used in production.

Casting Faults

It is possible to overcome most casting faults by adjusting the control values of the casting slip. The table below details most of the common faults encountered and suggests actions which may be taken to overcome these faults.

Fault	Description	Cause	Cure
poor filling	Too long to fill moulds	fluidity to low	increase water addition or increase deflocculant addition
flabby casts	soft casts - difficult to handle	thixotropy too high	increase deflocculant addition
brittle casts	hard casts - difficult to fettle	thixotropy too low	decrease deflocculant addition
poor draining	slip not draining from narrow sections	fluidity to low / thixotropy too high	increase water addition or increase deflocculant addition
wreathing	small uneven fringes on slip side of cast	thixotropy too low	decrease deflocculant addition or decrease water addition
pinholes	small holes just below surface on mould side of cast piece	fluidity to low	increase water addition or increase deflocculant addition
cracking	small cracks, e.g. where handle joins body of piece	thixotropy too low	decrease deflocculant addition or decrease water addition
casting spot and casting flash	discoloured patch occurring on the mould side of the article	fluidity to high / thixotropy too low	decrease water addition or decrease deflocculant addition

Practical Formulae

% Solids of a Suspension:

$$\% \text{ Solids} = \frac{\text{Solids SG}}{(\text{Solids SG}-1)} \times \frac{(\text{Density of Liquid}-1) \times 100}{\text{Density of Liquid}}$$

Brongniart's Formula:

$$\text{Dry Weight} = (\text{litre wt}-1) \times \frac{\text{Solids SG}}{\text{Solids SG}-1}$$

(Dry weight in kg/l)

Volume of Water needed to produce a Slip of Desired Solids:

$$\text{Volume} = \frac{\text{Dry Weight of Material}}{\% \text{ Solids Required}} \times (100 - \% \text{ Solids Required})$$

To Dilute 1 litre of Slip of Density A (kg/l):

$$\text{Volume of Water to Add} = \frac{A - B}{B - 1}$$

(Volume in litres)

A = Density of Slip
B = Required Density

Properties of Ceramic Materials

material	formula	molecular weight	oxides entering fusion	molecular weight of oxides	conversion factor	melting point °C	specific gravity
alumina calcined	Al ₂ O ₃	101.9	Al ₂ O ₃	101.9	1.0	2050	3.75
bone ash	Ca ₃ (PO ₄) ₂	310.3	CaO	56	0.542	1670	3.2
boro-calcite	2CaO.3B ₂ O ₃ .5H ₂ O	412	P ₂ O ₅	142	0.458		2.95
			CaO	56	0.271		
kaolinite (china clay)	Al ₂ O ₃ .2SiO ₂ .2H ₂ O	258.1	B ₂ O ₃	70	0.51	1770 (decomposes before melting)	2.52
			Al ₂ O ₃	102	0.395		
kaolinite, calcined	Al ₂ O ₃ .SiO ₂	222	SiO ₂	60	0.465	1770	2.6
			Al ₂ O ₃	102	0.46		
chromium oxide	Cr ₂ O ₃	152	SiO ₂	60	0.54	2070	5.04
			Cr ₂ O ₃	152	1.0		
cobalt carbonate	CoCO ₃	118.9	CoO	75	0.631	decomposes to oxide	
cobalt oxide	Co ₂ O ₄	241	CoO	75	0.934	2800	6.07
copper carbonate	CuCO ₃	123.6	CuO	79.57	0.645	decomposes to oxide	3.6 - 4.0
copper oxide	CuO	79.57	CuO	79.57	1.0	1149	6.4
dolomite	CaCO ₃ .MgCO ₃	184	CaO	56	0.304	decomposes to oxide	2.9
			MgO	40	0.218		
feldspar, potash	K ₂ O.Al ₂ O ₃ .6SiO ₂	556	K ₂ O	94	0.169	1200	2.5 - 2.6
			Al ₂ O ₃	102	0.183		
			SiO ₂	60	0.648		
feldspar, soda	Na ₂ O.Al ₂ O ₃ .6SiO ₂	524	Na ₂ O	62	0.118	1170 approx.	2.6 approx.
			Al ₂ O ₃	102	0.195		
			SiO ₂	60	0.687		
flint	SiO ₂	60	SiO ₂	60	1.0	1650-1750	2.2 - 2.6
ilmenite	FeO.TiO ₂	151-174	FeO	71-84	0.474		4.7
			TiO ₂	79.9	0.526		
iron chromate	Fe ₂ O ₃ .Cr ₂ O ₃	312	Fe ₂ O ₃	160	0.516	1800 approx.	4.5
			Cr ₂ O ₃	152	0.454		
iron oxide (ferrous oxide)	FeO	71.8	Fe ₂ O ₃	160	1.11		4.96 - 5.4
iron oxide (ferric oxide)	Fe ₂ O ₃	160	Fe ₂ O ₃	160	1.0	1565	5.2 - 5.3
iron oxide (ferroso-ferric oxide)	Fe ₃ O ₄	231.4	Fe ₂ O ₃	160	1.035	1538	5.0 - 5.5
lithium carbonate	Li ₂ CO ₃	7.4	Li ₂ O	30	0.405	618	2.1
magnesium carbonate	MgCO ₃	84.3	MgO	40.3	0.476	decomposes to oxide at 350	3.04
manganese carbonate	MnCO ₃	114.93	MnO	71	0.61	decomposes to oxide	3.6
manganese dioxide	MnO ₂	87	MnO	71	0.817	loses oxygen at 535	4.7 - 5.0
nepheline syenite	K ₂ O.3Na ₂ O.4Al ₂ O ₃ .8SiO ₂	1168	K ₂ O	94	0.080	1200 approx.	2.5 - 2.6
			Na ₂ O	62	0.158		
			Al ₂ O ₃	102	0.350		
			SiO ₂	60	0.412		
nickel oxide	NiO	74.7	NiO	74.7	1.0		6.6 - 6.8
petalite	Li ₂ O.Al ₂ O ₃ .8SiO ₂	612	Li ₂ O	30	0.049		2.4 - 2.5
			Al ₂ O ₃	102	0.167		
			SiO ₂	60	0.784		
quartz	SiO ₂	60	SiO ₂	60	1.0	1470	2.65
rutile	TiO ₂	79.9	TiO ₂	79.9	1.0	1600	4.2
sodium carbonate	Na ₂ CO ₃	106	Na ₂ O	62	0.585	852	2.5
sodium nitrate	NaNO ₃	85.01	Na ₂ O	62	0.365	310	2.27
sodium silicate	Na ₂ SiO ₃	122.1	Na ₂ O	62	0.508	1080	2.4
			SiO ₂	60	0.492		
spodumene	Li ₂ O.Al ₂ O ₃ .4SiO ₂	372	Li ₂ O	30	0.081		2.6
			Al ₂ O ₃	102	0.274		
			SiO ₂	60	0.645		
talc	3MgO.4SiO ₂ .H ₂ O	378.96	MgO	40.3	0.318		2.5 - 2.8
			SiO ₂	60	0.634		
tin oxide	SnO ₂	150.7	SnO ₂	150.7	1.0	1127	6.6 - 6.9
titanium oxide	TiO ₂	79.9	TiO ₂	79.9	1.0	1600	3.8
whiting	CaCO ₃	100	CaO	56	0.56	decomposes to oxide at 825	2.7 - 2.9
wollastonite	CaSiO ₃	116	CaO	56	0.48	1540	2.7 - 2.9
			SiO ₂	60	0.52		
zinc oxide	ZnO	81.3	ZnO	81.3	1.0	1800	5.6
zirconium oxide	ZrO ₂	123.2	ZrO ₂	123.2	1.0	2700	5.5
zirconium silicate	ZrSiO ₄	183.3	ZrO ₂	123.2	0.673	2550	4.56
			SiO ₂	60	0.327		

Pottery Faults and their Remedies

fault	appearance	cause	suggested remedies
pinholed glaze	pinholes in glaze after firing	<ul style="list-style-type: none"> ● gas evolution from body and / or glaze during firing: <ul style="list-style-type: none"> ■ under-firing of body ■ air trapped in clay ■ over-application and over-firing of underglaze colours ■ soluble salts ■ excessive whitening in the glaze ■ under-firing of the glaze ■ over-firing of the glaze giving rise to volatilisation 	<ul style="list-style-type: none"> ● fire body to recommended firing temperature ● wedge plastic clay thoroughly ● reduce application of underglaze colours ● add barium carbonate (0.1 - 0.25 %) to body to precipitate soluble salts ● reduce whitening in glaze ● fire glaze to recommended firing temperature ● reduce firing temperature of glaze
sulphuring	dull scum on glaze surface	<ul style="list-style-type: none"> ● sulphur gases present in kiln atmosphere reacting with glaze: <ul style="list-style-type: none"> ■ sulphates in body ■ sulphur present in kiln gases 	<ul style="list-style-type: none"> ● ventilate kiln as much as possible ● fire biscuit ware to temperature high enough to liberate carbon sulphur
blistering	large, often open, craters in glaze	<ul style="list-style-type: none"> ● gaseous materials being provided during firing: <ul style="list-style-type: none"> ■ glaze not fully matured ■ glaze/body over-fired ■ glaze and body are not fully compatible 	<ul style="list-style-type: none"> ● fire more slowly and/or soak at top temperature ● reduce length of firing/soak and/or drop temperature ● change the body/glaze combination
knocked glaze	bare unglazed patches	<ul style="list-style-type: none"> ● glaze rubbed or knocked off before firing 	<ul style="list-style-type: none"> ● handle more carefully and only when completely dry ● add a binder to the glaze (1% gum, starch or sodium carboxymethyl cellulose)
starved glaze	dull patches	<ul style="list-style-type: none"> ● glaze volatiles are sucked away from the surface by porous kiln furniture 	<ul style="list-style-type: none"> ● avoid placing new pots in glaze firing too close to kiln bricks or new props ● do not fire biscuit ware in the same firing as glost ware
stuck ware	ware stuck together or to kiln shelf	<ul style="list-style-type: none"> ● pots touching during glaze firing or too soft a glaze flowing down onto the shelf 	<ul style="list-style-type: none"> ● ensure pots do not touch in glaze fire ● wipe off glaze from base of pots ● use bat wash or placing powder
specking	dark specks	<ul style="list-style-type: none"> ● contamination - often from too many rusty tools or from loose particles of biscuit ware and applied decoration dropping onto glaze during dipping 	<ul style="list-style-type: none"> ● ensure all tools and containers are free from rust ● ensure pots are free of loose material before dipping ● sieve glaze regularly
blurring	blurred outlines on colours	<ul style="list-style-type: none"> ● high solubility of the colouring oxide to the colouring glaze 	<ul style="list-style-type: none"> ● experiment with an alternative glaze ● add clay to pigment ● reduce firing temperature
firing away	colours fading or disappearing	<ul style="list-style-type: none"> ● over-firing ● underglaze chrome tin pink may fade with glazes high in Boric Acid 	<ul style="list-style-type: none"> ● fire at lower temperature ● use an alternative glaze
ironing	copper coloured streak	<ul style="list-style-type: none"> ● too thick an application of underglaze decoration ● too thin an application of glaze over the cobalt 	<ul style="list-style-type: none"> ● apply decoration more thinly ● apply glaze more thickly
matt colours	matt texture	<ul style="list-style-type: none"> ● devitrification ● usually due to under-firing 	<ul style="list-style-type: none"> ● see devitrification ● fire at higher temperature or soak
on glaze colours crazing	fine cracks in colour surface	<ul style="list-style-type: none"> ● thermal expansion of colour not matching that of underlying glaze aggravated if colour applied to very 'stiff' porcelain type glazes 	<ul style="list-style-type: none"> ● apply colour thinner
purpling of gold	purple colour instead of gold	<ul style="list-style-type: none"> ● gold applied too thinly ● excessive use of thinners 	<ul style="list-style-type: none"> ● apply another layer ● use less thinners and apply thicker
peeling lustre	lustre peeling	<ul style="list-style-type: none"> ● ware not properly cleaned ● too much lustre applied ● fired too quickly after application 	<ul style="list-style-type: none"> ● clean with warm water and detergent ● apply more thinly ● allow to dry completely before firing

Pottery Fault and their Remedies

fault	appearance	cause	suggested remedies
bloating	bubbles from within body during firing	<ul style="list-style-type: none"> ● expansion of body produced by pressure build-up of gases trapped in a partially fused mass: <ul style="list-style-type: none"> ■ over-firing or irregular firing ■ carbon trapped within vitreous body ■ body too high in fluxes 	<ul style="list-style-type: none"> ● reduce firing temperature ● fire more slowly ● reduce flux content of body and / or grog to open up body
blow out	cratering in body	<ul style="list-style-type: none"> ● presence of impurities in clay or glaze: <ul style="list-style-type: none"> ■ particles or plaster from mould surface ■ sulphates and / or carbonates present in mould body 	<ul style="list-style-type: none"> ● avoid possible contamination: <ul style="list-style-type: none"> ■ remove any plaster plucked away from mould surface ■ use more refined clays
cracking	cracks in ware	<ul style="list-style-type: none"> ● rapid or uneven drying of clay ware ● clay of poor plasticity ● blunt turning tools ● firing body too fast up to 300 °C ● overworking of clay during making 	<ul style="list-style-type: none"> ● dry more slowly (invert mugs, jugs or bowls when of sufficient strength) ● increase plasticity of clay ● use sharper turning tools ● slow down initial firing rate (2-4 hours) ● reduce handling time during making
crawling	bare unglazed patches on surface of the pottery, glaze ruckled into small islands	<ul style="list-style-type: none"> ● excessive handling of ware before firing ● oil, grease, dust etc. on ware before glazing ● cracking of glaze layer during drying and before firing; ● excessive colloidal matter (clay) present in the glaze ● soluble salts present in the body ● over-application of the glaze 	<ul style="list-style-type: none"> ● minimise handling of ware before glazing ● keep biscuit ware clean ● handle dipped ware very carefully, reduce clay content of glaze ● add barium carbonate (0.1 - 0.25 %) to precipitate soluble salts ● reduce glaze application
crazing	fine cracks in glaze surface	<ul style="list-style-type: none"> ● mismatch of glaze and body thermal expansions (body should have higher expansion to maintain the glaze under compression) ● glaze applied too thickly ● moisture expansion of the body ● under-firing of body or glaze 	<ul style="list-style-type: none"> ● increase body expansion: <ul style="list-style-type: none"> ■ fire body to higher temperature ■ soak body for longer at peak temperature ■ increase silica content of body ● reduce glaze expansion <ul style="list-style-type: none"> ■ add silica or china clay to glaze ■ use Borax frit of lower expansion ● reduce glaze thickness ● reduce porosity of body
devitrification	glossy glazes appearing matt milky appearance of transparent glaze (often bluish-pink over terracotta bodies)	<ul style="list-style-type: none"> ● precipitation taking place during cooling of glazes: ● appearance of small crystals on surface of glaze (calcium, zinc silicates etc.) ● milky precipitate (calcium borate) 	<ul style="list-style-type: none"> ● cool more quickly down to 700 °C (i.e. while the glaze is still semi-molten) ● reduce lime content of the glaze ● add china clay to glaze ● use low solubility glaze instead of leadless glaze
dunting	splitting of ceramic ware due to silica inversion (when glaze has run into crack: dunting has occurred during heating cycle; crack with sharp edge: dunting has occurred during cooling cycle)	<ul style="list-style-type: none"> ● too rapid heating and /or cooling of body especially around 573 °C and 220 °C (silica inversion temperatures) ● body too high in silica ● large variations in wall thickness or article giving rise to thermal gradients ● over-firing of body 	<ul style="list-style-type: none"> ● fire and cool the body more slowly through temperature ranges at which silica inversions take place ● reduce silica content of the body ● give careful consideration in design ● reduce firing temperature of the body ● open up by addition of grog
peeling	glaze lifting away from body (occurs mainly on edges of post such as cup rims and handles)	<ul style="list-style-type: none"> ● glaze under excessive compression ● migration of soluble salts to surface of body on drying or firing giving rise to poor adhesion of glaze 	<ul style="list-style-type: none"> ● reduce body expansion: <ul style="list-style-type: none"> ■ reduce firing temperature ■ reduce body soaking period ● increase glaze expansion: <ul style="list-style-type: none"> ■ add high expansion alkaline frit ■ reduce silica and /or alumina content of glaze ● add barium carbonate (0.1 - 0.25 %) to body to precipitate soluble salts ● sponge rims and handles of clay ware before biscuit firing

Glossary of Terms

Ark

Tank in which clay slip is agitated and/or stored

Blunger

Tank with mixer for the production of clay slips or slurries

Body, Ceramic

Workable mixture of clays and non-plastic materials with properties suitable for firing, from which ceramic products are made

Casting Slips

Ceramic bodies mixed with water and deflocculant to form a slurry

Deflocculant

Reagent used to disperse agglomerates to achieve fluid slips at higher density

Dunting

Cracking in fired ceramics which have undergone uneven heating or cooling

Fettling

The removal of rough edges, mould marks and irregularities from unfired ceramic ware, usually through abrasion, scraping or cutting

Frit

Melted glass, quenched in air or water to produce small friable particles which are milled for use in porcelain enamels, fritted glazes and frit chinaware

Grog

Ground refractory materials used as a raw material to improve working properties in refractories, terracotta, stoneware, vitreous china sanitaryware and similar products

Reagent

A reactive chemical, e.g. a deflocculant

Thermal Expansion

Reversible or permanent change in the dimensions of a body

Thixotropy

The property of a suspension to be fluid when agitated or thicken when stationary

Viscosity

Is the measurement of a fluid's resistance to flow

Vitrification

Progressive reduction in a body's porosity due to heat treatment and fusion, during which a glassy or non-crystalline material is formed

Volatilization

Conversion of a chemical substance from a solid/liquid state to a gas through the application of heat or a reduction in pressure

Wreathing

Slightly raised crescent shape on the inside wall of slip-cast ware

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WBB MINERALS

www.wbbminerals.com

Ceram

www.ceram.co.uk

American Ceramic Society

www.acers.org

Institute of Materials

www.materials.org.uk

European Industrial Minerals Association

www.ima-eu.org

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