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TECHNICAL GUIDES

Pigment & Coating Colour Preparation

IMERYS
Paper & Packaging

Pigment & Coating Colour Preparation

Because of faster coater speeds and increased quality related demands, an often neglected but nevertheless, important aspect of the total coating process is the dispersion of pigments and the subsequent preparation of coating colour.

The main aim of this guide is to provide useful, practical guidelines for users of coating pigments in the paper industry in order to maximise throughputs at high solids levels. These guidelines will be of benefit in situations requiring either modification /uprating of existing kaolin dispersion systems in particular and pigment screening systems in general, or the design of a new system.

This paper, therefore, sets out to outline recent developments in pigment and coating colour preparation. Emphasis has been given to the dispersion of kaolin and the subsequent pigment screening operation with particular consideration given to fine mesh pigment screening using open vibrating screens.

Although materials such as calcium carbonate or talc will normally be processed as slurries or supplied as such, kaolin will often be delivered in a dry or partially dry state. Before preparing a coating colour, kaolin will therefore need to be converted into a high solids aqueous slurry, requiring a disperser which usually demands the highest power of any mixer in the coating kitchen. In general, this will be a trouble free operation since the processes involved are not complicated.

The importance of setting realistic objectives for various grades of kaolin cannot be over stated thus avoiding serious problems. Nevertheless, increases in solids levels and dispersion rate can often be made, if suitable techniques are employed, **within the safe operating limits of the equipment.**

In view of the increased demands in the coating kitchen in terms of throughput and quality, it has been necessary in many papermills to use finer screens for screening both pigment and coating colour, also it has become necessary to increase the production rate through the screening station.

Using finer screens and increasing the screening rate means that often screen cloth life will be reduced. Screen cloth life, therefore, has become an important factor, not only because screen cloths are expensive but, more importantly, their failure could result in oversize material finding its way to the coating station.

Even though the cloth life of screens can be dramatically increased, papermills often require additional second stage screens in order to minimise the risk of streaking. Although this can be taken care of by simply installing additional units it has the disadvantages that it occupies more floor space and more operator surveillance is required.

A less expensive alternative to this is two deck screening – a system currently under evaluation for both kaolin and calcium carbonate slurries.

Methods of improving screening rate, the use of two deck screens and extending cloth life will be discussed in this guide.

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Kaolin Dispersion

Making down or dispersing a coating clay means producing a homogeneous suspension of clay in water at the solids concentration required. In order to produce a high solids well dispersed clay at minimum viscosity, it will be necessary to consider both the chemical demands of the clay and the physical aspects of dispersion.

Great care should be taken to ensure that the kaolin suspension is optimally dispersed using a suitable dispersing agent, normally either a sodium polyphosphate, a sodium polyacrylate or combinations thereof. In order to provide a fluid suspension to between 7 and 7.5 using caustic soda; an accepted procedure for establishing the dispersant demand is included in Appendix I.

The Physical Aspects of Dispersion

Broadly speaking the physical aspects of dispersion can be divided into three phases. Although here separated in order to simplify explanation, there will be a certain degree of overlap in each case.

WETTING

The first phase is wetting and this occurs from the beginning of pigment addition and for a few minutes after the addition period. The importance of presenting the feed material to the water phase is critical. If the addition rate is too fast the product will "ball up" into lumps sometimes in excess of 400mm diameter which could cause damage to the disperser and will in any case reduce the dispersion rate. If the addition rate is too slow a reduction in dispersion rate will take place. This is true not only because of the obvious additional time due to the slower addition, but also because of solids concentration of the suspension is lower for a longer period of time; under these circumstances it is difficult to impart energy to the slurry.

An idealised disperser feed system will have a variable speed so that the early stages of addition are fast, slowing down towards the end of the addition period when the specific gravity of the suspension is at its highest and the feed clay tends to float. The importance of a vortex and fast material transfer are both necessary for effective wetting and will be discussed under the heading 'Disperser Design'.

DEAGGLOMERATION

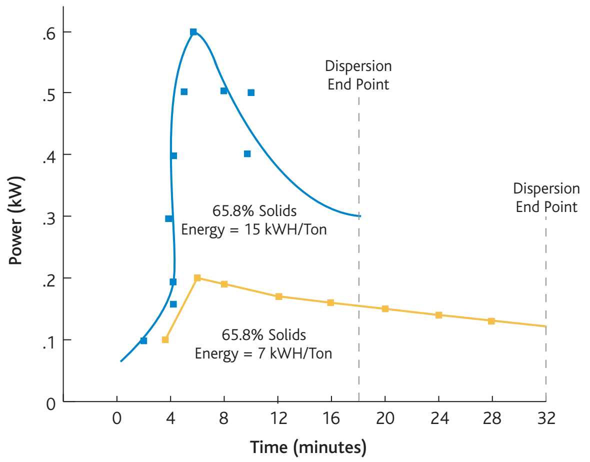
In order to reduce the lumps and agglomerations of clay to a level where, in most cases, considerably more than half of the particles are below 2 microns will require high shear forces. The efficiency of dispersion, therefore, will be function of shear rate in the high shear zone and the rate of material transfer through the high shear zone.

The power requirement of the motor will, at high solids, also be dependent upon the suspension viscosity when the flow is either laminar or transitional. At low solids when the Reynolds number is greater than 100 and the flow is said to be turbulent the power needed for dispersion is to a large extent independent of the suspension viscosity.

In practice, provided sufficient material transfer is taking place, it is advantageous to increase the solids concentration to such a level that the motor is taking just below its rated operating current. At this point the velocity gradient is at its highest in the shear zone and the dispersion rate is also at its highest. The effect of this is illustrated in Figure 1 which shows a typical power time curve for an English coating clay dispersed at two solid levels using a 20 litre Cellier laboratory disperser.

Since energy is a function of power and time, at higher solids more energy can be imparted to the suspension for a given dispersion time. For this reason it is extremely important that pigments are accurately dispersed to the intended solids concentration.

Figure 1: Power Variation during Fine Coating Kaolin



Makedown

In order to control the solids concentration the following considerations should be taken into account:-

- the moisture content of the pigment should be checked on a regular basis (a sample of moist clay is weighed before and after drying).
- the pigment should be accurately weighed into the vessel, either using load cells on the vessel or weigh bins.
- the weight of water for dispersion should be accurately measured (usually using a water meter).

A number of density meters (see Appendix II) have been evaluated for controlling the final concentration of the suspension:

a. weighed loop
b. vibrating tube
c. pressure differential
d. "Nucleonic type"

While all those mentioned above perform reasonably well, care should be exercised in ensuring that the meter is installed in a suitable position in the pipeline. Often meters are installed after elbows or bends in pipelines or close to pumps; inaccuracies then occur due to the presence of air.

LIQUID WORKING

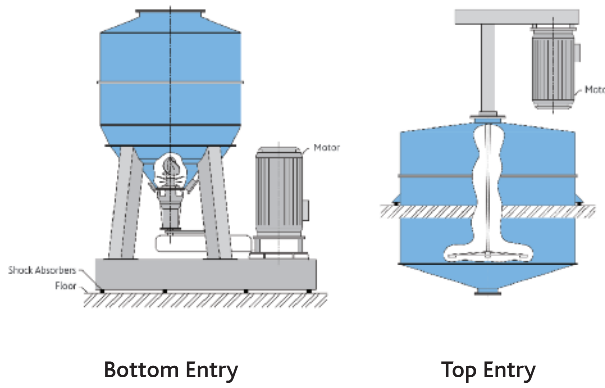
Following the deagglomeration phase it is normal practice to continue the dispersion process for an extra five to ten minutes in order to produce a more fluid suspension. This process, known as "liquid working", is believed to modify slightly the particle shape possibly rounding the corners of particles and/or removing small projections from individual particles.

DISPERSER DESIGN

Stripped to its essentials, the liquid disperser, is a turbine mounted at the end of a vertically mounted shaft and operating in a vessel which contains pigment and water.

The drive for the disperser can be from above the vessel (top hung mixer) or from below the vessel (bottom entry). The general arrangement for each of these dispersers is shown in Figure 2.

Figure 2: Disperser Design



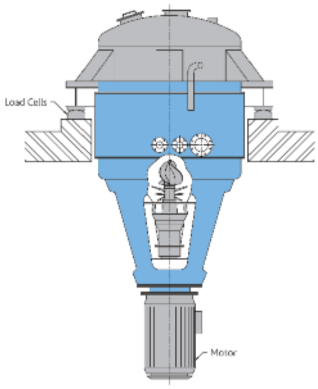
In the form in which it is depicted in Figure 2 above, the bottom entry mixer provides a very stable structure with easy access to the vessel. The main disadvantage of this style of disperser is that it cannot easily be mounted on load cells because the motor and transmission system are mounted separately from the vessel. The top hung disperser, on the other hand, is readily mounted on load cells but can be prone at high solids to be less stable than the bottom entry type due to the long shaft which might cause vibration. The vibration in turn can adversely affect the accuracy of the load cells.

Many bottom entry dispersers are, these days, supplied with a direct drive motor as shown in Figure 3, which means that is also is readily mounted on load cells.

Consideration in the design of the disperser should be given to the rate of material transfer through the high shear zone and the shear rate generated in the high shear zone.

Both tooth-disc turbines (Figure 4) and bar turbines (Figure 5) will provide a reasonable compromise between material transfer rate

Figure 3: Bottom Entry Mounted on load Cells



and shear rate. The bar turbine typically provides a very high material transfer rate with a reasonable degree of shear. The tooth-disc turbine at 3000 rpm will give a very high shear rate in the impeller zone ca 600 sec^{-1} for a dilatant suspension.

Figure 4: Bar Turbine

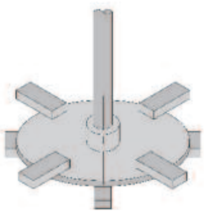
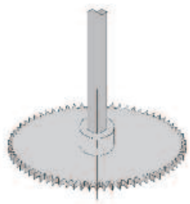


Figure 5: Tooth-Disc Turbine



BAFFLES

Another feature of dispersers which impedes flow into the high shear zone is baffles.

Adding baffles to the wall of the disperser will increase the power requirement of the mixer without increasing the shear rate or improving the rate of dispersion.

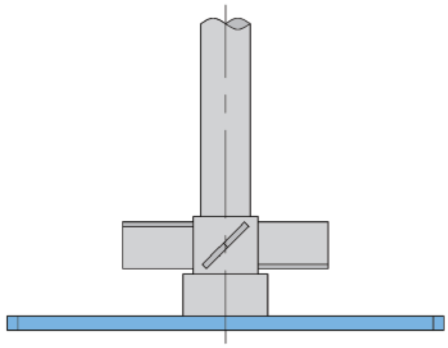
Furthermore toward the end of the clay addition stage, as the specific gravity of the suspension increases, there is a tendency for the clay, especially if it is in a spray dried form (a product form with a low bulk density), to float. Since the breakdown of lumps occurs in the high shear zone, a vortex is required in order to transfer the product from the surface to the turbine. Baffles tend to break the vortex thereby reducing the dispersion rate.

If, however, the vortex extends from the surface into the eye of the turbine, air will be sucked into the suspension. In sophisticated systems, microphones have been used to sense vortex depth. If the depth is too great the impeller speed, which is proportional to vortex depth, is automatically reduced. For larger mixers, however, although the theory holds true, in practice it is extremely expensive to use variable speed motors. Under these conditions it is advisable to reduce the speed by changing the pulley diameters of the transmission systems. An alternative to this is to adjust the depth of the turbine relative to the surface.

This is accomplished by mounting the drive motor and the complete transmission system including the shaft and turbine onto an adjustable hydraulically operated table.

The material transfer, however, will be significantly less than that of a bar turbine. For this reason many dispersers with toothed-disc turbines have two turbines on the same shaft in order to promote material transfer. A better method, however, is to mount an axial flow turbine immediately above the toothed disc turbine in order to create a vortex (see Figure 6); the amount of power consumed will be considerably less than that of two tooth-disc turbines. The degree of material transfer will, however, be significantly higher.

Figure 6: Tooth-Disc Turbine with additional Axial Flow Turbine



Attempts, by manufacturers, have been made to shroud the turbine with a stator, thus providing a high shear zone, and "suction stacks" are used to promote flow into the impeller. In practice, however, according to the writer's experience, although a high shear rate is generated the flow into the high shear zone is restricted. As a result a very lengthy addition time is evidenced along with limitations to the solids concentrations achievable. In many cases the shroud and suction tube have been removed, the impeller changed to a bar type, and as a result large increases in dispersion rate have been recorded.

SCREEN PLATES

It has also been established that screen plates installed below the turbine to prevent undispersed lumps of clay from leaving the disperser, as shown in Figure 7, or vertically positioned screen plates as used in recirculating systems as shown in Figure 8, will also severely limit the degree of material transfer. Removal of these screen plates will almost certainly result in a shorter pigment addition time, a shorter overall dispersion time and a higher achievable solids level.

Figure 7:

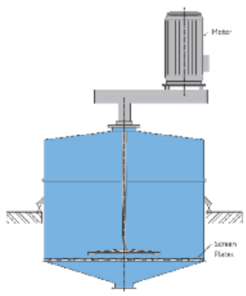
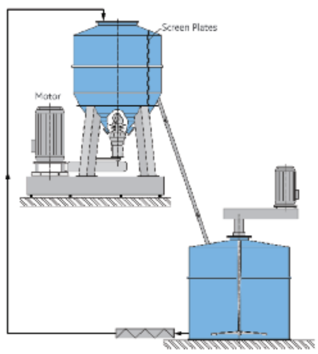


Figure 8:



Pigment Screening

SCREENING RATE

In general the rate at which a pigment slurry or coating colour screens will depend upon the following factors:-

- the mesh shape and size of the cloth;
- the "screening pattern" (directional movement of residue above the cloth caused by the vibration of the screen);
- the head of slurry or coating colour above the cloth;
- the rheological properties of the suspension;
- the quantity of oversize material in the suspension.

MESH SHAPE AND SIZE

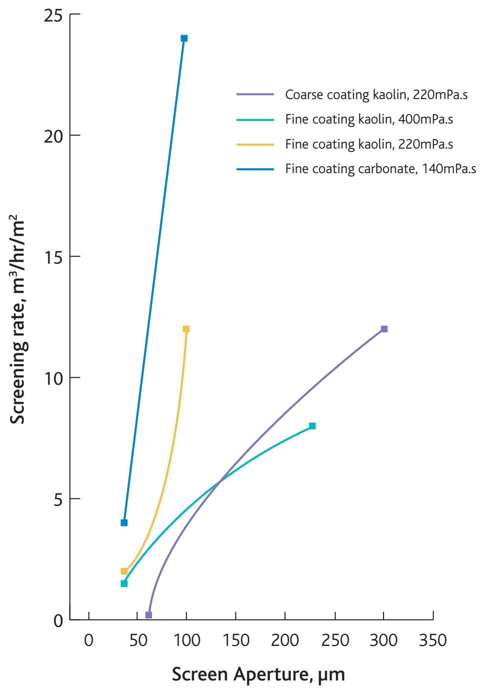
The mesh size can only be fully described when the following factors have been considered:-

- the number of holes per unit length or area
- the aperture size and shape
- the wire diameter
- the "open area"
- the type of weave

Any of the above will significantly affect both screening rate and cloth life.

The data contained in Figure 9 were generated on a 500mm pilot scale screen and test rig. using various mesh sizes. The angle and mass of the weights were optimised and the slurry head above the cloth was 5cms.

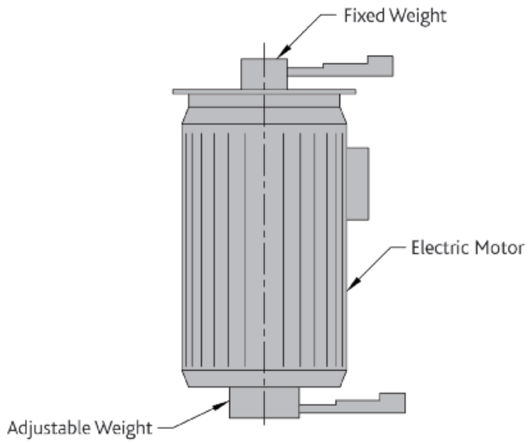
Figure 9:
All slurry values are quoted at Brookfield 100rpm.



THE SCREENING PATTERN

The screening pattern of an open vibrating screen is caused by the vibration generated by eccentrically loaded weights, situated above and below a vertically installed electric motor (see Figure 10 below).

Figure 10: Vertically Installed Electric Motor



Changes in the screening pattern, and hence changes in screening rate will require either adjusting the angle or mass of the eccentrically loaded weights. Figure 11 shows the screen displacement in millimetres of a 1.2m dia screen for three weight positions. Figure 12 shows movement of oversize material over a range of weight angles.

Figure 11: Screen Displacement (mm)

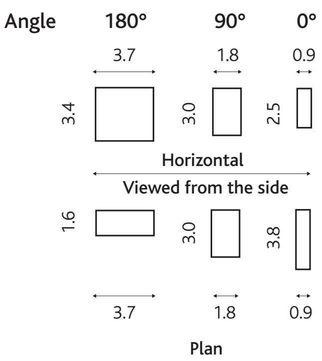
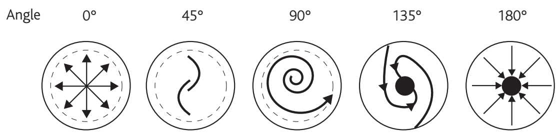


Figure 12: Screening Pattern



As a general rule, increasing the bottom weights creates more vertical movement to the screen and increasing the top weight creates more horizontal movement.

Provided the screen cloth is well tensioned up to a ca 20% increase in screening rate can be achieved by "finely tuning" the weight value(s) and angle(s).

The Effect of Slurry Head on Screening Rate

Experimental work, using full scale equipment, has shown that the height of slurry above the screen cloth dramatically affects the screening rate. As the height increases, the screening rate increases. On the debit side, however, if the height or head of slurry is significantly above 5cms, it will contribute to reducing the cloth life.

Figure 13 shows that for a coarse particle coating clay at 64.2 wt % solids, the screening rate increases from around 2m¬^{3}/hr to around 5m^3/hr by increasing the head from 1cm to 5cms. These results were based on a warm slurry (40°C) using a 1.2 metre diameter screen equipped with a 150 BS mesh (100 micron) cloth.

An ever large improvement (2.8m^3/hr to 10m^3/hr) is seen for a fine coating clay over the same range (the coarser coating clay is slightly dilatant over the shear rate range generated on a screen and does not therefore respond to an increase in head in quite the same way as the finer less dilatant pigment). A similar effect is shown for a fine calcium carbonate slurry with minus 2 micron fraction of 95%. At 1000mPa.s* (Brookfield viscosity at 100rpm) the screening rate increases from ca 5m^3/hr to ca 13m^3/hr as a result of increasing the head from 1cm to 5cms. The calcium carbonate data were obtained using a 1.2m diameter screen.

Experience has shown that the highest screening rates for china clay slurries are obtained when the bottom weight 'leads' the top weight by between 45° and 90°. The vertical displacement under these conditions will be between ca 2.7 and 3.0mm. The horizontal displacement will be between ca 1.2 and 1.8mm. The lateral displacement will be between 3.0 and 3.7mm.

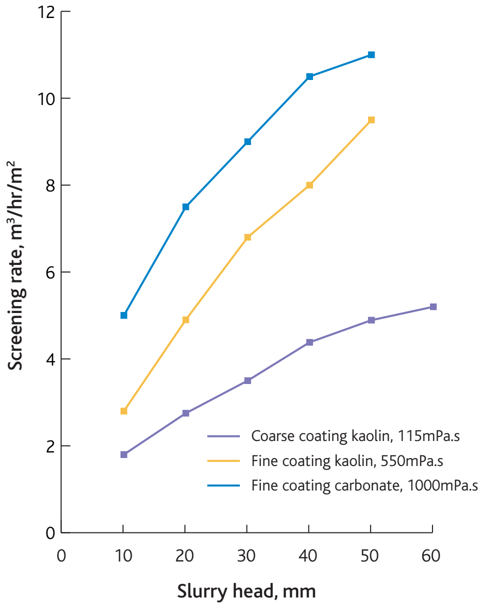
It can be seen from Figure 12 that the 45° angle provides an ideal method of removing oversize material. The residue moves outwards from the centre of the screen tangentially and then forms a 'rope' at the periphery of the screen bowl.

As the angle increases from 45° to 90°, the outward movement tends to spiral taking longer to travel to the periphery of the bowl. Under these conditions, after prolonged use without cleaning (when the amount of oversize material increases on the cloth surface), blinding will occur, with a corresponding reduction in screening rate.

If, therefore, the level of oversize material is low, faster screening rates can be obtained using a 90° angle. If, however, the level of oversize material is high, more reliance needs to be placed on the removal of oversize material in order to maintain a reasonable screening rate. Under these circumstances, it is recommended that a 45° angle is used.

The mass of the weights will also significantly contribute to the screening rate. Certain screens have fixed weights and no attempt should be made to add to them; such action can cause failure of the electric motor bearings.
Other screens, however, are designed in such a way that additional weights can be added to the top and bottom of the electric motor. Experience has shown that the fastest screening rates are achieved when the maximum weight is used.

Figure 13:
All slurry viscosity values are quoted at Brookfield 100rpm



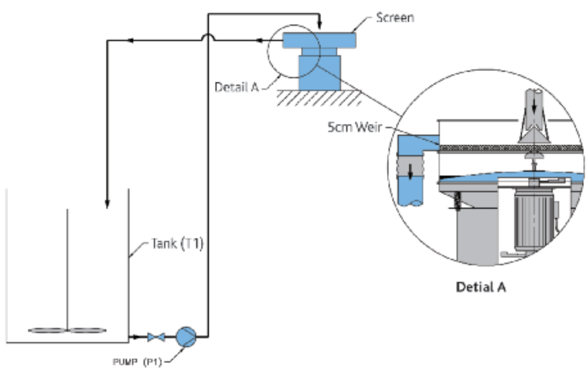
* *1000 mPa.s is considerably higher than the IMERYS specification for carbonate slurries. In this case, and in other cases in this guide, where the viscosity for carbonate slurries are above 400 mPa.s, the carbonate has been left without agitation for a considerable time period in order to create a gel structure for trial purposes only.*

In practice, however, it can be extremely difficult to maintain a more or less constant head above the cloth. Two methods, however, that work extremely well are described below:-

a) Overflow Method – see Figure 14

For this system it is important that the screens are situated higher than the product feed tank (or dump tank T¬¬1¬). The slurry is pumped (P1) to the screens. The screen cloth is flooded and a 5cm head is obtained. The slurry then overflows the weir (item A) and flows by gravity back to the dump tank.

Figure 14: Constant Head - Overflow Method

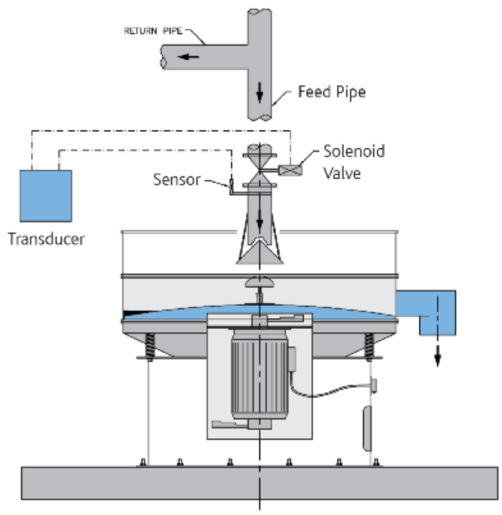


This system is very simple, works well, is inexpensive and requires the minimum amount of supervision.

and **b)** Using Ultrasonic Sensors – see Figure 15

This system is used if the screens cannot be positioned higher than the dump tank.

Figure 15: Constant Head - Ultrasonic Sensor



An ultrasonic sensor is installed approximately 50cms above the screen cloth. When the slurry level reaches the 5cms height above the cloth, the ultrasonic sensor sends a signal to a solenoid via a transducer which partially closes the feed valve.

When the level falls to say 4cms height the feed valve partially opens.

This method works well but tends to be expensive to install.

It is extremely important that a return pipe is used in this system so that when the valves are partially closed during operation or even completely closed for maintenance/cleaning purposes the feed pump delivery is not restricted.

The Effect of Rheology on Screening Rate

It is demonstrated in Figures 16 and 17 that screening rate of a pigment slurry can not be determined by its Brookfield viscosity alone.

Calcium carbonate slurries, for example, exhibit strong pseudo plastic behaviour and are rheopectic (viscosity increases with time). Experience using both open vibrating screens and in-line filters, has shown that it is extremely important to shear the calcium carbonate slurry before screening.

Experimental data have demonstrated that only a modest shear rate is necessary to destroy the rheological structure (see Figure 18).

Empirically, it has been demonstrated that the rheological structure can preferentially be destroyed using a motionless mixer. A motionless mixer comprises a length of tube containing a broken helix; depending upon the flow and apparent viscosity of the suspension, the pressure drop, across the mixer, required in order to destroy the structure would not typically be greater that 0.5 bar.

Figure 16: Fine Calcium Carbonate - 5cm head - 1.2m screen

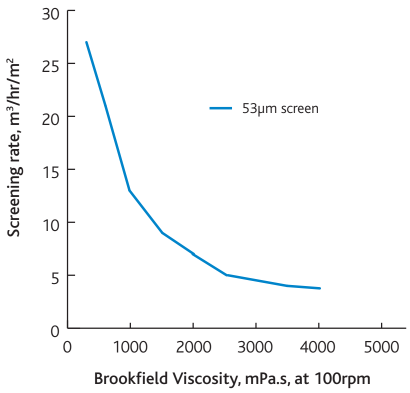


Figure 17: Fine and coarse coating kaolins - 5cm head - 0.5m screen

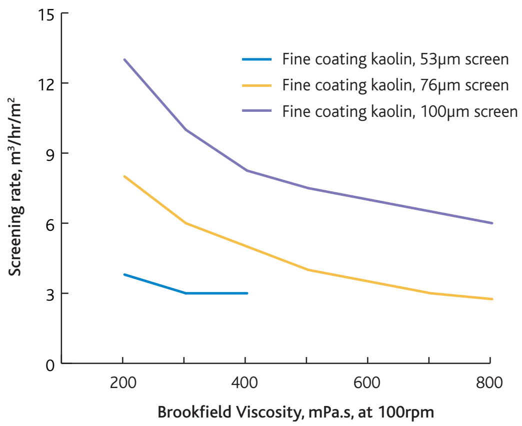
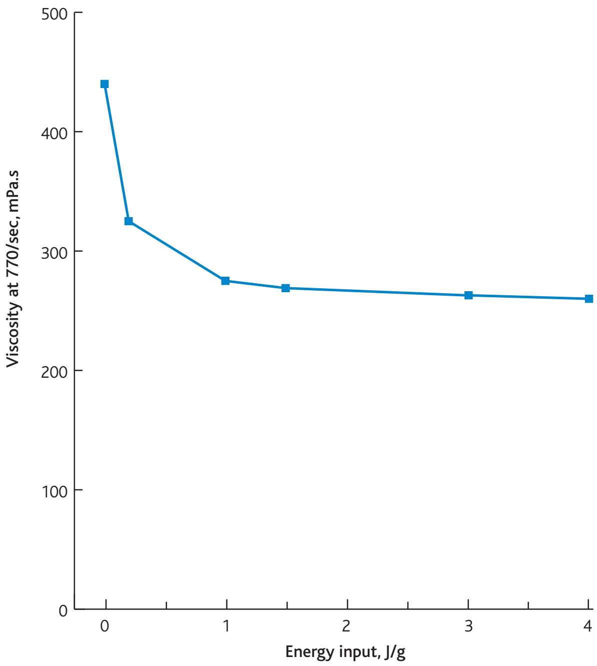


Figure 18: Viscosity at 770/sec vs Energy input



Pigment & Coating Colour Preparation

For example, using a 50mm diameter by 1 meter long motionless mixer, the 100rpm Brookfield viscosity of a fine calcium carbonate slurry was reduced from 750 mPa.s, after pumping and immediately before the mixer, to 180 mPa.s after the mixer. The flow was 10.28 m³/h and the pressure drop across the mixer only 0.5 bar. Such a large change in viscosity will dramatically increase the screening rate. The installation of a static mixer immediately before a pressure filter will have a similar effect. As a result the frequency of backwashing can be significantly reduced.

Laboratory analysis has shown that many coating colours exhibit similar pseudo plastic behaviour and should respond in a similar manner to calcium carbonate suspension.

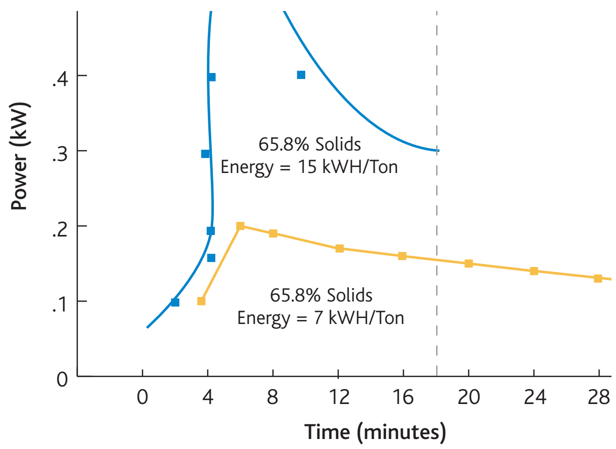
The Effect of Motor Speed on Screening Rate

It has been established that pigments which contain 'platey' particles tend to dewater at the surface of the screen cloth. This is the case for coarse coating clays.

The coarser platelets, some of which might be in excess of 10 microns diameter tend to lie flat, bridging across the cloth aperture. Dewatering can, thus, be recognised by the formation of a 'cake' or barrier level immediately above the cloth surface. A specimen of this 'cake', sampled from the cloth surface, will reveal an increase in the coarse fraction together with an increase in solids concentration. When dewatering occurs, the screening rate for the first two to three minutes, is often quite fast but then reduces rapidly.

If the motor speed of the screen is increased from the standard speed of ca 1440rpm, the screening rate will also increase (see Figure 19). The reason, it is believed, is because at higher vibration frequencies, the particles that were lying in a horizontal mode, causing bridging, begin to rotate. In their vertical mode they fall, relatively freely, through the aperture; the 'barrier layer' disappears and the screening rate increases.

Figure 19: Screening Rate vs Motor Speed for coarse coating kaolin



Due to slight changes in the rheological properties of a pigment, the optimum motor speed required to provide a maximum screening rate might vary. Under these circumstances a frequency inverter should be connected to the electric motor of the screen so that the optimum motor speed can be selected.

Many coating colours and calcium carbonates which exhibit pseudo plastic behaviour will also screen faster when high motor speeds are used.

It should be understood that the increased vibration can to some extent reduce the life of the screening unit. The effect of this can be offset by applying a suitable stress relief technique to the screen components, e.g. vibration treatment or heat treatment (normalising).

Two Deck Screening

It is strongly recommended that to prevent oversize material reaching the coating head, coating pigment slurries are screened at least twice before coating colour preparation. In certain circumstances, due to manning levels or limited space, it is not practicable to have more than one set of units.

When this is the case, it is possible to use either:

- a safety net system; or
- a true two deck system.

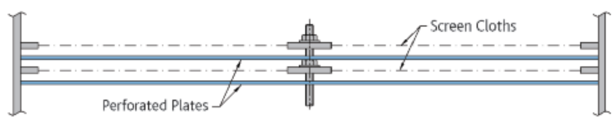
SAFETY NET SYSTEM

As its name suggests, the safety net is a secondary cloth installed a short distance below the nylon support rings (see Figure 20). The cloth, used for the safety net, must be coarser than the top cloth. It is reasoned that if the top cloth fails, the residue tends to form a cohesive lump and is, therefore, preferentially retained on the secondary cloth.

The IMERYS slurry plant in Finland uses this system successfully. The screens installed in this plant are equipped with 80 micro cloths on the top and 150 micron on the bottom. The two disadvantages of this system are:-

i) the bottom cloth cannot be inspected under operating conditions;
ii) there is a risk that if the top cloth fails, some oversize material might go into the process.

Figure 20: Safety Net



TWO DECK SCREEN

In the author's opinion, this is the ideal method of two stage screening.

At IMERYS, in Cornwall, two deck systems are being evaluated for low solids, flocculated clay slurries. Figure 21 shows an ideal unit.

If a slightly coarser screen is used for the top deck, most of the residue is removed before the slurry passes onto the secondary fine cloth. This will have the effect of:

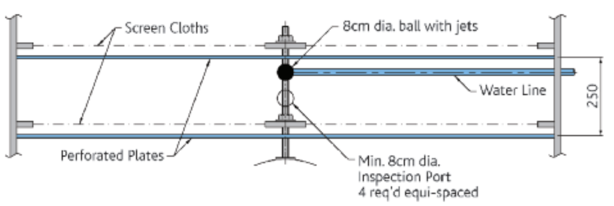
- increasing the cloth life of the secondary screen; and
- increasing the overall screening rate because very little residue will be present to cause "cloth blinding" on the secondary screen.

Experience has shown that the spacer section between the two screens should be at least 25cms deep. This allows enough space between the two cloths for easy inspection.

At least four inspection holes, equal-spaced around the screen, are required. These should be at least 80mm in diameter and can be covered with rubber grommets when not in use, to prevent splashing.

A further important feature is the high pressure (3-4 bars) water spray system using an 8cm diameter stainless steel ball containing ½mm diameter jets. This system cleans both the top surface of the secondary cloth and also the bottom surface of the cloth. The washing can be effected periodically and preferably automatically. It is important that if the washing is automated, the screen product valve should be closed automatically and the screen residue valve opened automatically. After washing, the valve status should be automatically reversed.

Figure 21: Two Deck Screen



The disadvantage of this system is that the bottom deck is not easily inspected, even with 80mm diameter ports. It is also important that a 30° ramp is installed on the discharge spout of the screen bowl to permit automatic residue removal while, at the same time, maintaining a head of slurry above the cloth.

CLOTH LIFE

The trend mentioned earlier to use finer cloths results in a considerable reduction in cloth life, because finer wires are used.

Various methods to extend cloth life have been evaluated, both at IMERYS' slurry plants and also at customer's premises.

At a mill in Scandinavia, the cloth life for a 53 micron cloth was at best only two days; this was extended to between one month and two months.

The original screen was equipped with a mushroom central support system as illustrated in Figure 22. This system is suitable for coarse cloths (coarser than 100 microns), the mushroom serving effectively to halve the otherwise unsupported span.

For mesh sizes finer than 100 microns, it is extremely important to use a ring support system as illustrated in Figure 23. The rings collectively form a uniform cloth support across the whole of the screen diameter.

When the screen is operating the rings rotate in the opposite direction to the electric motor. This action also tends to clean the underside of the cloth which under running circumstances significantly increases the screening rate.

The screen was therefore converted to accept the unclogging ring system but the improvement in cloth life was only slight.

Figure 22: Screen with Mushroom Central Support System

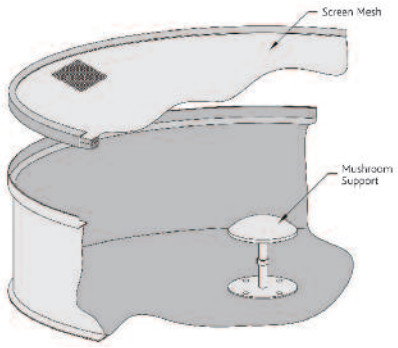
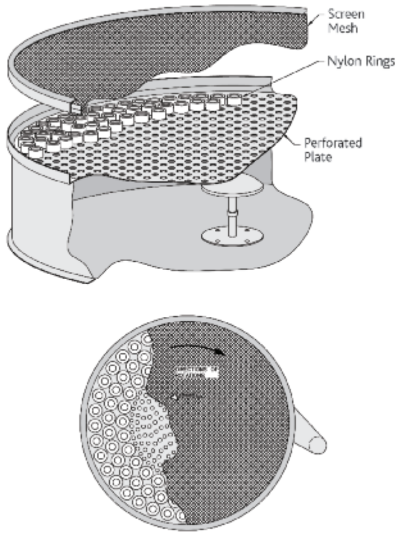


Figure 23: Screen with Perforated Plate & Support Rings



A "factory tensioned" cloth was then used to replace a conventional mill mounted cloth and frame. The tension of the "factory tensioned" cloth was significantly greater. The screen was modified to accept the centre support pad of the SWECO frame (see Figure 24). The nut 'A' was adjusted to provide a 1mm clearance (approximately) between the upper surface of the nylon ring and the lower surface of the cloth. It has been demonstrated that with zero clearance at this point, cloth life is drastically reduced.

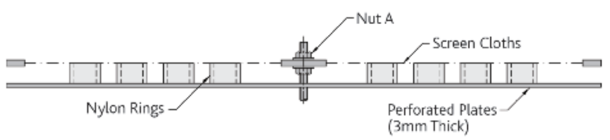
In practise the 1mm clearance disappears when the screen is flooded (as is normal and correct) and the rings then act as a cloth support. Under these conditions with much greater cloth tension, the cloth life was increased by up to 2 months.

As a result of the increased cloth tension and the cleaning action of the rings, the screening rate also increased significantly.

Pigment & Coating Colour Preparation

It might be reasoned that using "factory mounted" cloths is more expensive than the mill mounting its own cloths in the traditional way. If, for this reason, the mill elects to mount its own cloths, it is strongly recommended that the cloth be suitably tensioned using a "tensioning table". This practice is used at IMERYS' slurry plant in Lixhe, Belgium.

Figure 24: Setting up details - Using Ring Support System



Conclusions

More efficient kaolin dispersion and improved pigment and coating colour screening might result from considering the following checklists:

KAOLIN DISPERSION

1. Ensure that the pigment feed system matches the dispersion characteristics, for example when dispersing pigments with a high final specific gravity or delivered pigments with low bulk densities a variable speed or two speed feeder should be considered, thus eliminating the risk of floating pigment at the end of the dispersion cycle.

2. The turbine should be designed to provide both sufficient shear as well as adequate material transfer. In situations where this is not the case, for example a disperser installed with a tooth-disc turbine, it might be advantageous to install an additional turbine, of the axial flow type, which will improve the degree of material transfer without significantly increasing the energy level.

3. Baffles should be removed from the walls of dispersion vessels in order to promote material transfer as well as significantly reducing the dispersion energy level.

4. Screen plates situated below the turbine or, in recirculating systems, situated just before the product discharge port will also significantly restrict material transfer and should be removed.

PIGMENT AND COATING COLOUR SCREENING

1. Ensure that the mesh size is appropriate for the screening duty for which it has been assigned, in terms of:

   a. removal of oversize material – size and shape of the aperture;

   b. throughput - the open area of the cloth as well as the size and shape of the aperture;

   c. cloth life – the type of weave and the wire diameter.

2. The cloth should be correctly tensioned using a proprietary tensioning table.

3. Optimise the screening pattern in terms of screening rate and residue removal. This is accomplished by checking and adjusting, if necessary, the relative position and mass of the eccentric weights above and below the electric motor.

4. A more or less constant head of slurry or coating colour should be maintained above the cloth in order to maintain maximum throughput. This is best achieved by ensuring that the screen is situated above the feed tank. The pipe work can then be arranged in such a way that a 5cm weir is installed with an overflow system returning to the feed tank.

   In situations where this is not possible ultrasonic sensors can be installed, connected in conjunction with an automatic feed valve.

5. Consideration should be given to the rheological characteristics and particle size of the material to be screened.

   For example, pigment slurries and coating colours which exhibit pseudo-plastic rheological behaviour, often screen more rapidly immediately after being sheared. Increasing the motor speed of the screen will also significantly increase the screening rate of such suspensions.

   Increasing the motor speed will also often result in increasing the screening rate of coating pigments with large platey particles which, under "normal circumstances", tend to de-water just above the surface of the cloth.

6. Cloth life and screening rate will both be improved if the correct cloth support system has been installed (mushroom supports for coarse cloths and "unclogging rings" for fine cloths.

7. In situations where the product requires screening twice and where both operator time and floor space are at a premium, two deck screening using either the "safety net" system or a two deck screen incorporating an automatic "between deck" washing system could be considered.

IMERYS Test Method – High Solids Dispersant Demand

1. Definition

The High Solids Dispersant Demand of a slurried material is the mass of dispersant required to establish the minimum viscosity of that slurried material at a fixed solids concentration. This may also be referred to as the quantity of dispersant required to give optimum deflocculaton. It is expressed as a percentage of the mass of the dry material in that slurry.

2. Scope

This test is used to determine the conditions of optimum deflocculation of all materials. It may be carried out as a precursor to the viscosity concentration test. Slurried materials are tested as received, whereas other materials are slurried at an initial solids concentration equal to that of the flowability. The test is normally carried out at pH 7.0 although it may be carried out at other pH's and is then expressed as the High Solids Dispersant Demand at that pH.

3. Apparatus

3.1 ECC high speed mixer
3.2 Balance; to weigh 200g ± 0.1g
3.3 Mixing pot; brass or stainless steel, capacity 200ml, I.D. about 50mm
3.4 Viscometer; Brookfield R.V.
3.5 Modified Brookfield No.3 spindle. NOTE: The modification requires he removal of the end of the shaft at a point approximately 3mm below the disc.
3.6 Bench stirrer.
3.7 Spatula modified with cross bar.
3.8 Miscellaneous; burettes 50ml and 25ml, graduated pipettes 10ml and 1ml with suction bulb, beakers 100ml plastic, thermometer 0 – 110°.

4. Reagents

4.1 Water; deionised.
4.2 Sodium hydroxide 4% w/v, or sodium carbonate 5% w/v.
4.3 Sodium polyacrylate 25% w/v (active).
4.4 Sodium hexametaphosphate (Calgon) 25% w/v.

5. Method for Acid Flocculated Clays

5.1 Refer to the flowability test and following the method for acid flocculated clays determine and record the flowability.
5.2 Refer to the high solids Alkali demand test and following the method for acid flocculated clays determine and record the amount of alkali required to raise the pH to 7.0 or the pH value requested.
5.3 Measure this required amount of alkali from a burette into a clean and dry mixing pot.
5.4 Measure out and add 0.4ml of the deflocculant solution using a burette or graduated pipette. NOTE: This dose rate is equivalent to 0.1 mass %.
5.5 Weigh out 100g of dry test sample to within 0.1g.
5.6 Add sufficient deionised water to the mixing pot such that when 100g of the dry test sample are added the solids concentration is 3 mass % greater than the flowability.
5.7 Locate the mixing pot on the high speed mixer, lower the shaft, and add approximately half the quantity of sample.
5.8 Switch on the mixer and start adding the remainder of the sample at such a rate that the mixture just remains fluid.
5.9 Complete the addition. During and after this operation it may be necessary to prevent excessive build up of the sample on the side of the pot. This is removed and returned to the bulk of the slurry using the spatula. If the slurry thickens to the point of solidification, reduce the solids content by 1 mass % with deionised water and record this dilution. NOTE: The sample addition should be completed within approximately one quarter of the total mixing time. If this is not achieved then repeat 5.3 to 5.9 at a reduced initial solids content of 1 mass % to that given in 5.6.
5.10 Continue mixing until the time for 25,000 revolutions of mixer shaft or 17 minutes have elapsed. Switch off the mixer and remove the pot.
5.11 Measure and record the temperature of the slurry.
5.12 Cool the slurry to room temperature and transfer it to a 100ml beaker using a spatula to ensure complete transfer.
5.13 Attach a clean and dry spindle to the viscometer and immerse it in the slurry to the groove and centralise.
5.14 Set the speed of the viscometer to 10rpm and switch it on.
5.15 Increase the speed to 100rpm and allow the spindle to rotate for 15 seconds.
5.16 Depress the brake lever and whilst keeping it depressed reduce the speed to 10rpm. Switch off the viscometer when the needle is visible.
5.17 Note the viscometer reading, release the brake and record the reading. NOTE: If using a digital viscometer record the reading displayed after 15 seconds in 5.15.
5.18 Add 0.08ml of dispersant, using a 1ml pipette, and mix thoroughly using the viscometer spindle.
5.19 Re-attach the spindle to the viscometer, immerse it in the slurry to the groove and centralise.
5.20 Repeat steps 5.14 to 5.19 until the reading reaches a minimum value and starts to increase.
5.21 The total amount of dispersant added at this minimum reading is the dispersant demand.

6. Method for Predispersed Clays

6.1 Refer to the flowability test and following the method for predispersed clays determine and record the flowability.
6.2 Refer to the High Solids Alkali Demand test and following the method for predispersed clays determine and record the quantity of alkali required to raise the pH to 7.0 ± 0.1 or the pH value requested (refer to Scope). NOTE: If the pH is 7.0 or above proceed to 6.4.
6.3 Measure this required amount of alkali from a burette into a clean and dry mixing pot.
6.4 Repeat steps 5.5 to 5.21.

7. Expression of Results

The dispersant demand is expressed as the mass % D and is calculated as follows:

$$\text{Mass \% D} = \frac{V + [v \times 0.25]}{W} \times 100$$

Where:-

V = the dispersant does (mass %) added at the start of the slurry makedown. (NOTE: For predispersed clays this will be zero.
v = the volume of dispersant added during test.
W = the weight of test material.

8. Precision

Not quoted.

9. Instrument Suppliers

9.1 Brookfield R.V. Viscometer: Brookfield Engineering Laboratories Inc., 240 Cushing Street, Stoughton, Massachusetts 02072, U.S.A.
9.2 High speed mixer: IMERYS.

Pigment & Coating Colour Preparation

Product Forms

SPRAY DRIED KAOLIN

Spray dried products are pre-dispersed and very fine.

Size of spheres: 150 µm in diameter
Bulk Density: 800 Kg/m^3
Angle of repose: 30°
Moisture content: 1%-6% (depending on requirements)
Densified forms (about 12% moisture) are available on request

GRANULATE

Kaolin in granulate form is produced in a Pin Mill.

Size of Lumps: Fines – 40mm diameter pieces
Bulk Density: 995 Kg/m^3
Angle of repose: 33-41°
Moisture: 18% (±2%)

10% MOISTURE KAOLINS

Lump Kaolin is produced in Rotary Driers and in some Buell Driers.

Size of Lumps: Fines – 40mm diameter pieces
Bulk Density: 900-1100 Kg/m^3
For storage calculations: 1000 Kg/m^3
Angle of repose: 32-36°
Moisture: 10% (±2%)

Pelletised kaolin is produced in Buell driers.

Size of pellets: Below 20mm in diameter
Bulk Density: 900-970 Kg/m^3
Angle of repose: 32-36°
Moisture: 10% (±2%)

18% MOISTURE KAOLINS

Tube pressed kaolin is produced by a high pressure tube filter press.
No thermal drying is involved.

Size of pieces (Average): Fines to 10mm x 50mm x 100mm
Bulk Density: 1000 – 1200 Kg/m^3
Angle of repose: 32-36°
Moisture: 18% (±1.5%)

POWDER KAOLIN

Powder kaolin is produced by milling.

Bulk Density: 180-350 Kg/m^3 (when freshly aerated)
290-500 Kg/m^3 (after standing)
Moisture: 1% (Average)

Kaolin Slurry Properties

Table of typical slurry properties

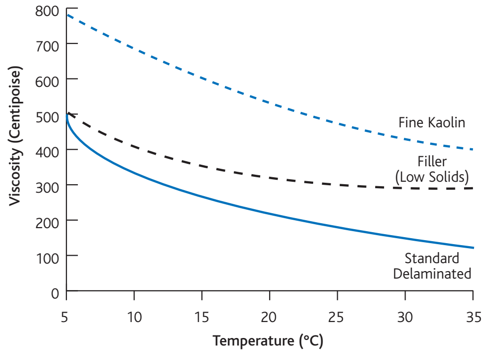
Quality	% Solids	Viscosity* (centipoise)	Specific Gravity
Fine	70	500	1.77
Delaminated	64	210	1.66
Coarse	66.5	210	1.70

**Measured by Brookfield Viscometer at 100 rpm and 22°C.*

These viscosity figures vary and are for guidance only.

SLURRY KAOLIN

Variation in Viscosity with Temperature



EQUATION FOR CALCULATING THE SPECIFIC GRAVITY

Specific Gravity =

$$\frac{100}{\dfrac{\%\ \text{solids}}{\text{SG of kaolin}} + \dfrac{100-\%\ \text{solids}}{\text{SG of water}}}$$

SG of Kaolin 2.64
SG of Water 1.00

or

$$\frac{1}{1-\dfrac{(\%\ \text{Solids})}{161}}$$



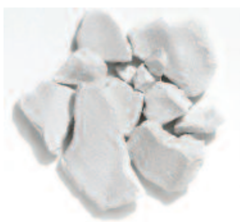


Table showing the specific gravity and dry kaolin content

% Solids	Specific Gravity	Dry kaolin content Kg/m³	% Solids	Specific Gravity	Dry kaolin content Kg/m³
20	1.142	228	60.0	1.594	956
21	1.150	241	60.5	1.602	969
22	1.158	255	61.0	1.610	982
23	1.167	268	61.5	1.618	995
24	1.175	282	62.0	1.626	1008
25	1.184	296	62.5	1.635	1022
26	1.193	310	63.0	1.643	1035
27	1.202	324	63.5	1.651	1049
28	1.211	339	64.0	1.660	1062
29	1.220	254	64.5	1.668	1076
30	1.229	369	65.0	1.677	1090
31	1.238	384	65.5	1.686	1104
32	1.248	399	66.0	1.695	1118
33	1.258	415	66.5	1.704	1133
34	1.268	431	67.0	1.713	1148
35	1.278	447	67.5	1.722	1162
36	1.288	464	68.0	1.731	1177
37	1.298	480	68.5	1.741	1192
38	1.309	498	69.0	1.750	1207
39	1.320	515	69.5	1.760	1223
40	1.331	532	70.0	1.769	1238
			70.5	1.779	1254
			71.0	1.789	1270
			71.5	1.799	1286
			72.0	1.809	1302

Reception and Dispersion of Bulk Kaolin

CONTROL SYSTEMS
In a kaolin handling and dispersion installation, control is required over the following operations.
1. Kaolin addition rate and total weight.
2. Slurry concentration.
3. Amount of water and chemical additives.
4. Dispersion time.

1. KAOLIN ADDITION

The maximum kaolin addition rate that the disperser can accommodate changes as the dispersion cycle progresses. It is therefore necessary to either feed the kaolin at a constant rate equivalent to the maximum possible at any stage in the cycle or to vary the rate according to the position in the dispersion cycle. If the former method is adopted the disperser will be operating at low efficiency for the majority of the cycle. The latter system is preferable but does require a more sophisticated control system. Two possibilities are available: the power consumption of the disperser drive motor or the elapsed time from the beginning of the cycle. The latter method is most commonly used.

2. SLURRY CONCENTRATION

If on-line indication of slurry concentration is required the following systems are available:
Weighing pipe loop (suitable up to 30% solids)
Gamma Ray absorption
Ultra Sonic detection

3. CHEMICAL ADDITION

Either integrating electro magnetic flow meters or dispersion vessel mounted on load cells can be used. If the latter system is adopted it must be sufficiently sensitive to record small quantities of, for example, chemical dispersants. Dosing pumps can also be used for chemical addition.

4. DISPERSION TIME

This function is easily controlled by simple process timers.

Pigment & Coating Colour Preparation

Cubic meters of water required to make down one tonne (1000kg) as received at various moisture contents.

Moisture Content of Product %	% Solids of Finished Slurry (Kaolin)													
	59	60	61	62	63	64	65	66	67	68	69	70	71	72
0	0.695	0.667	0.639	0.613	0.587	0.563	0.531	0.515	0.493	0.471	0.449	0.425	0.408	0.389
1	0.677	0.650	0.623	0.597	0.571	0.547	0.523	0.500	0.478	0.456	0.435	0.414	0.394	0.375
2	0.661	0.633	0.607	0.581	0.555	0.531	0.508	0.485	0.463	0.441	0.420	0.400	0.380	0.361
3	0.644	0.617	0.590	0.565	0.540	0.515	0.492	0.470	0.448	0.426	0.406	0.386	0.366	0.347
4	0.627	0.600	0.573	0.548	0.524	0.500	0.477	0.455	0.433	0.412	0.391	0.371	0.352	0.333
5	0.610	0.583	0.557	0.532	0.508	0.484	0.461	0.439	0.418	0.397	0.377	0.357	0.338	0.319
6	0.593	0.567	0.541	0.516	0.492	0.469	0.446	0.424	0.403	0.382	0.362	0.343	0.324	0.306
7	0.576	0.550	0.525	0.500	0.476	0.453	0.431	0.409	0.388	0.368	0.348	0.329	0.310	0.292
8	0.559	0.533	0.508	0.484	0.460	0.438	0.415	0.394	0.373	0.353	0.333	0.314	0.296	0.278
9	0.542	0.517	0.491	0.468	0.444	0.421	0.400	0.379	0.358	0.338	0.319	0.300	0.282	0.264
10	0.525	0.500	0.475	0.452	0.429	0.406	0.385	0.363	0.343	0.324	0.304	0.286	0.268	0.250
11	0.508	0.483	0.459	0.436	0.413	0.391	0.368	0.348	0.328	0.308	0.290	0.272	0.253	0.236
12	0.492	0.466	0.443	0.419	0.396	0.375	0.353	0.333	0.313	0.294	0.275	0.257	0.239	0.222
13	0.475	0.450	0.426	0.403	0.381	0.359	0.338	0.318	0.299	0.279	0.261	0.243	0.225	0.208
14	0.458	0.433	0.410	0.387	0.365	0.344	0.323	0.303	0.284	0.265	0.246	0.229	0.211	0.194
15	0.441	0.417	0.393	0.371	0.349	0.328	0.308	0.288	0.269	0.250	0.232	0.214	0.197	0.181
16	0.424	0.400	0.377	0.355	0.333	0.313	0.292	0.273	0.254	0.235	0.217	0.200	0.183	0.167
17	0.407	0.383	0.361	0.339	0.317	0.297	0.277	0.258	0.239	0.221	0.203	0.186	0.169	0.153
18	0.390	0.367	0.344	0.323	0.302	0.281	0.262	0.242	0.224	0.206	0.188	0.171	0.155	0.139
19	0.373	0.350	0.328	0.306	0.286	0.266	0.246	0.227	0.209	0.191	0.174	0.157	0.141	0.125
20	0.356	0.333	0.311	0.290	0.270	0.250	0.231	0.212	0.194	0.176	0.159	0.143	0.127	0.111

Table showing Specific gravity and dry carbonate contents

% Solids	Specific Gravity	Dry carbonate content Kg/m³	% Solids	Specific Gravity	Dry carbonate content Kg/m³
20	1.144	228.9	51	1.475	752.0
21	1.153	242.1	52	1.488	773.9
22	1.161	255.5	53	1.502	796.3
23	1.170	269.0	54	1.517	819.1
24	1.178	282.8	55	1.532	842.3
25	1.187	296.8	56	1.546	866.0
26	1.196	311.0	57	1.562	890.2
27	1.205	325.4	58	1.577	914.8
28	1.215	340.1	59	1.593	939.9
29	1.224	355.0	60	1.609	965.6
30	1.234	370.1	61	1.626	991.7
31	1.243	385.4	62	1.643	1018.4
32	1.253	401.0	63	1.660	1045.7
33	1.263	416.8	64	1.677	1073.5
34	1.273	432.9	65	1.695	1102.0
35	1.283	449.2	66	1.714	1131.0
36	1.294	465.8	67	1.732	1160.7
37	1.305	482.7	68	1.752	1191.1
38	1.315	499.9	69	1.771	1222.1
39	1.326	517.3	70	1.791	1253.8
40	1.338	535.0	71	1.812	1286.2
41	1.349	553.1	72	1.833	1319.4
42	1.361	571.4	73	1.854	1353.4
43	1.372	590.1	74	1.876	1388.2
44	1.384	609.1	75	1.898	1423.8
45	1.397	628.4	76	1.921	1460.3
46	1.409	648.1	77	1.945	1497.7
47	1.422	668.2	78	1.969	1536.0
48	1.434	688.5	79	1.994	1575.2
49	1.448	709.3	80	2.019	1615.5
50	1.461	730.5			

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