Coating Colours Preparation
General Principles
Influence of Some Parameters on The Colours and Coated Papers Characteristics

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INTRODUCTION

The coating colour applied on the surface of a paper or board is a water based mixture of different types of chemicals:

- mineral pigments which give the optical properties : brightness, opacity, gloss, smoothness and improve the printing aptitude,
- binders for adhesion of pigments particles between them and on the base,
- additives useful for colour preparation, application on the web and also coated paper properties.

The formulation - grade of chemicals, proportions - is the result of know-how of the paper maker or chemist. A lot of compromises have to be found in order to obtain all the required properties in the same time for the best aspect and printing aptitude of the finished paper.

If the choice of the formulation is one of the keys of a successful coating operation, a suitable colour preparation, installation and working procedures, constitute an other condition for that success.

The updated high speed machines require the use of perfectly reliable colours: rheology, viscosity, consistency.... free of harmful elements and entrapped air which could give application's defects.

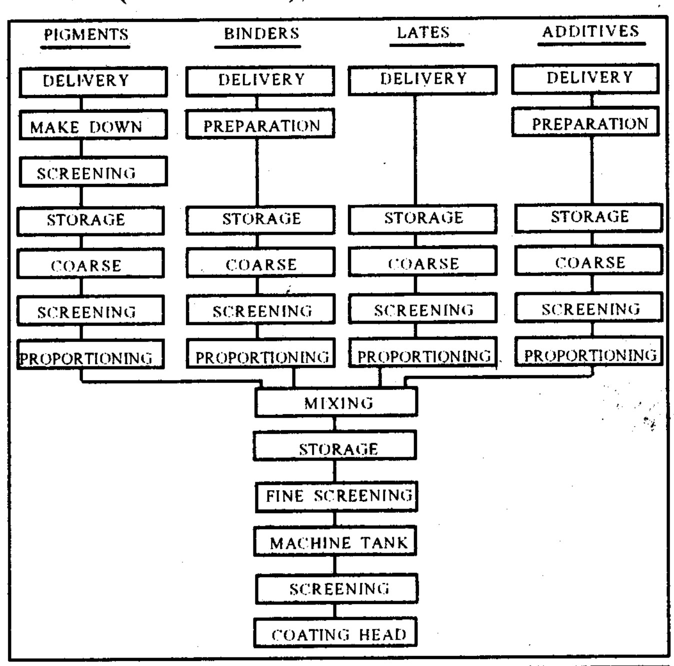
PRINCIPLE OF COATING COLOUR BATCH PREPARATION

The chemicals are supplied in liquid (ready to use) or dry form.

The annexed sketch Nr Al shows the different steps of a colour preparation and coating head supply.

The main steps which require specific pieces of equipments are:

- Preparation in liquid form of chemicals delivered in dry form:
  * dispersion of the pigments,
  * dissolution of cobinders - starch CMC, PVA, Protein.... - and some additives,
- Transfer and proportioning of the liquid components in a mixer, blending,
- Coating head supply and colour filtration (screening) : fresh colour and returns from the coating head (recirculation),



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The pigments dispersion, liquids mixing and filtration will be discussed in the following paragraphs.

Different ways exit for the proportioning of the liquid components:

Main components: pigments, cobinders, latex.....
* weighing by load cells of the mixer or hoppers dedicted to each component. The mixer weighing supposes that the different chemicals are not transfered simultaneously in the mixer which leads to a longer preparation time.
* flow meters on each component.
  mass flow meters (coriolis effect) which permit also to know the density,
  or electromagnetic flow meters.

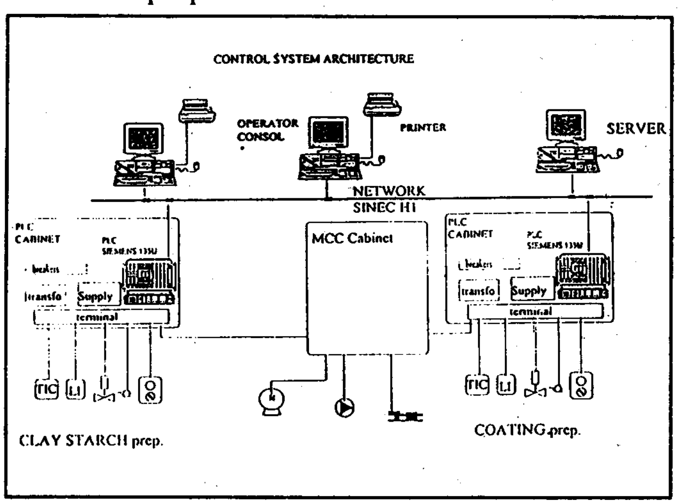
Additives:
* flow meters,
* metering pumps and timers.

The accuracy of the proportioning and in a general way the reliability of the colour characteristics are widely facilitated by a fully automatised plant.

The annexed sketch Nr A2 shows the control system architecture of a colour preparation with the three levels:

* Level 0	Field instruments and activators
* Level 1	Programmable logic controller
* Level 2	Supervision with a PC: management of formulation, production, chemical stock......

CELLIER has developed a special software for colour preparation: PAPCEL.



If the colour preparation is generally realised according to a batch process, some mills prefer a continuous preparation.

PIGMENTS MAKE DOWN

Clay, Calcium Carbonate, Calcined Clay, Aluminium Trihydrate, Titanium Dioxide, Talkum.....

Satin white is always delivered in liquid form or prepared directly in the paper mill.

The elementary particles of pigments which size is in the range of a macrometer, depending of the type and remaining humidity, are aggregated in pieces of variable size, from a fine powder to lumps of several centimeters.

The object of the pigments make down is to produce an acquous suspension (or slurry) in which the particles are totally separated the ones from the others.

The operation is realized in a special mixer in which are introduced water, dry pigments and additives.

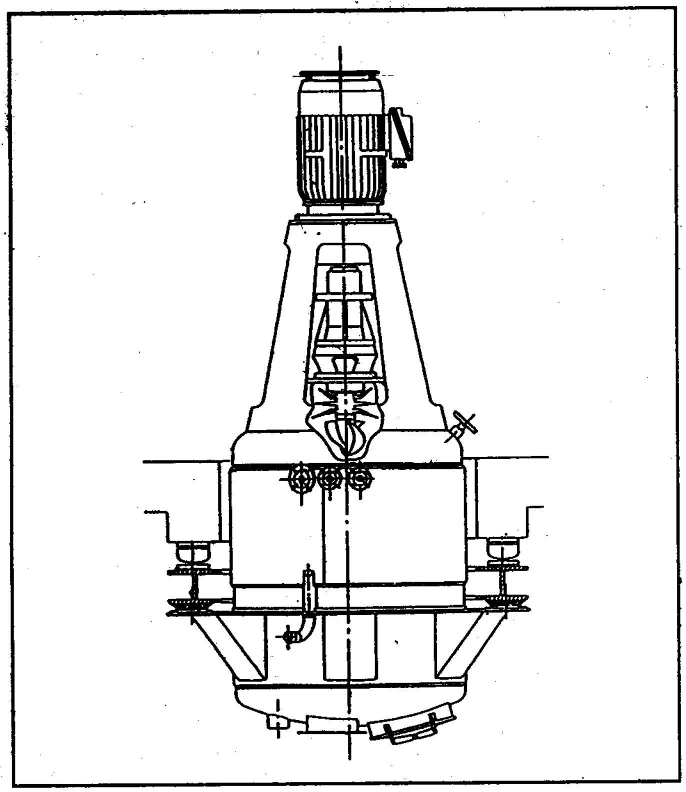
Two different effects contribute to the deaggregation:

* Mechanical effect by the mixer agitator which develops shearing forces and also shocks between particles, more numerous at high solids content,
* Chemical effect with the additon of dispersing agent which modifies the electrochemical charge at the surface of the particles and also PH adjustment.

The slurry viscosity decreases during the first agitation time after the end of the dry pigment loading in the mixer. The dispersion is considered as finished and of good quality when the viscosity is stabilized; for a given solids percent of the slurry the lower the viscosity after stabilization, the better the dispersion.

The choice of the dispersing agent grade and the addition at the optimum ratio are also very important for the viscosity level and its stability during the storage time.

The mixer proposed for the pigments make



down, the DELITEUR, includes a cylindrical shell with conical base and an agitator located at the bottom part of the shell (see annexed sketch A3).

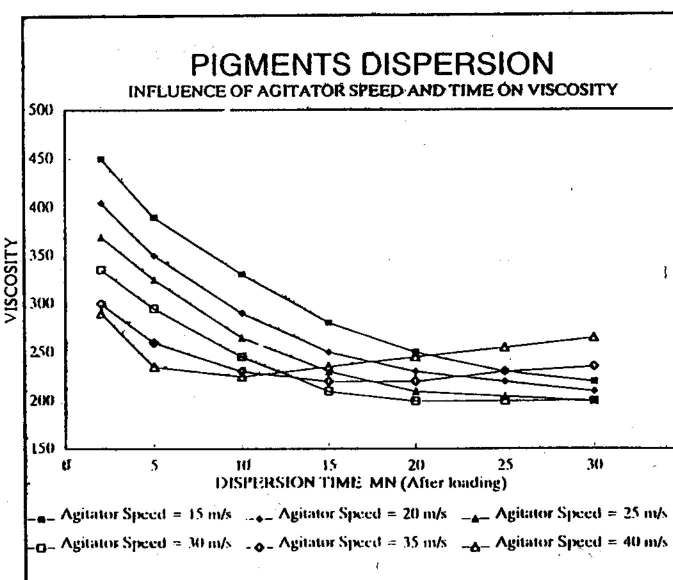
That agitator is equipped with blades and at the upper part of a special turbine called "nose".

The DELITEUR presents some very interesting advantages:

- Agitation at the bottom part:
  * more space available on the top for the arrangement of the different chemicals arrivals,
  * less vibrations or risks of resonance,
  * gravity center below the support level which permits a very good accuracy of the proportioning by weighing load cells,
  * possible pigments loading at high cadence without mechanical risks in case of lumps or blocks.
- Dual function: blending and dispersing with the three bladed agitator and pumping system (nose).
  * high pumping capacity which creates a central vortex necessary for the blending of dry components and water and homogeneity of the mixture,
  * shear effects of a double type:
    between particles created by the blades and pumping effect,
    rotor-stator effect created by the proximity between the blades and the conical base of the shell.

  Optimized shearing effect. The agitator speed is adjusted for:
  * total destruction of pigments aggregates but without breaking of elementary particles which would give a poor rheology of the coating colour and unreliable coated paper characteristics.
  * optimum peripherical speed in the range 25-30 m/s give the lowest and constant viscosity of the slurry after a minimum time of agitation which indicates a total dispersion without particles destruction.

Some examples are given on the annexed graph A4 which shows the viscosity evolution versus agitation (dispersion) time after the end of powder loading. At low speed, the viscosity is not yet stabilized after 30 mn, too much long time for an industrial installation. At intermediate speed 25 - 30 m/s, the viscosity remains constant after 20 minutes; the dispersion is finished. At speed over than 30 m/s, a minimum viscosity is quickly observed but at a higher level than the one obtained at 25-30 m/s; then we observe a significant increase with a longer agitation time. That means that elementary particles are broken or delaminated (case of clay or talkum). So, depending of the agitation time (more or less a few minutes is enough), the viscosity - rheology of the coating colour and the properties of the finished paper will be different.



LIQUID COMPONENTS MIXING

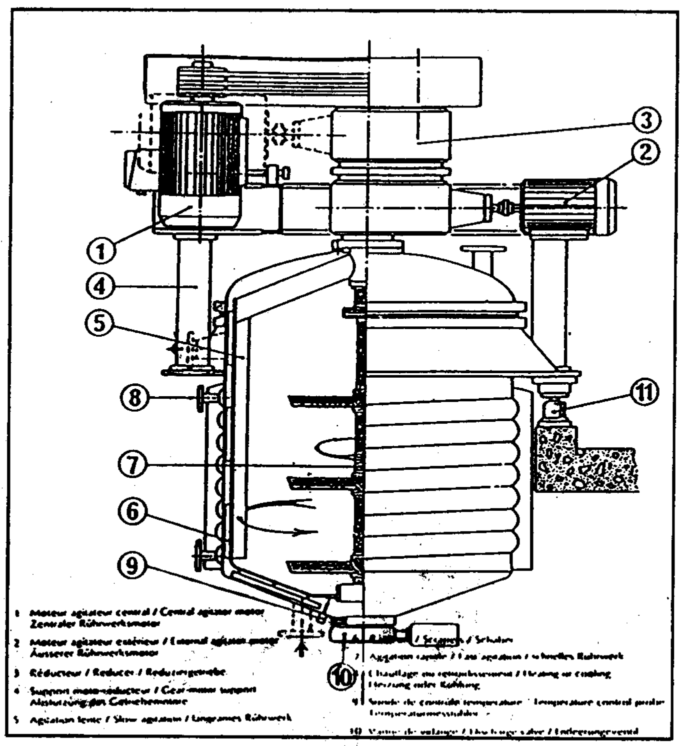
As for the pigments make down, the two main characteristics of a mixer used for the blending of liquid components are the pumping capacity and shearing effect.

Mixers with pendular agitator can be used with shafts equipped of different types of elements giving more or less shear or pumping effect, depending from the kind of mixture to be treated.

In comparison, the DELITEUR used for pigments dispersion is also a very performant mixer for the blending of liquid components. its use is highly recommended in the case of great volumes due to its very high pumping capacity.

A special mixer, the DELICEL, is used in case of very high viscosity mixtures (high solids starch preparation, satin white preparation, special coating formulations). The DELICEL (see annexed sketch A5) is equipped with double agitation:

* high speed central agitation for shearing effect and circulation,
* low speed peripherical agitation (scrapers) in the opposite direction of rotation to clean the shell wall and bring back the mixture in the center to be sheared by the central agitator.



A good balance between shearing effect and pumping effect is quite necessary when some small quantities of dry chemicals have to be added directly in the colour preparation mixer; for instance dispersion of auxiliary pigments or dissolution of cobinder like CMC, protein, cold solube starch.... when very high solids contents are required.

Shearing effect on coating colour viscosity

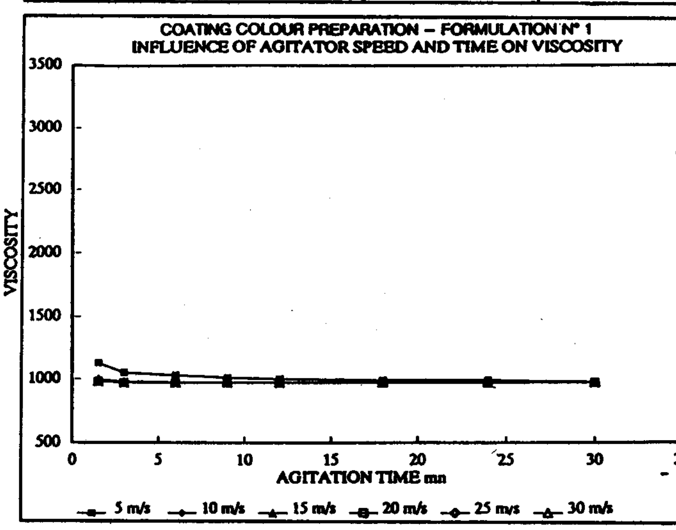
The viscosity/ rheology of the coating colour is more or less influenced by the shearing effect - agitation speed and time- depending from the formulation.

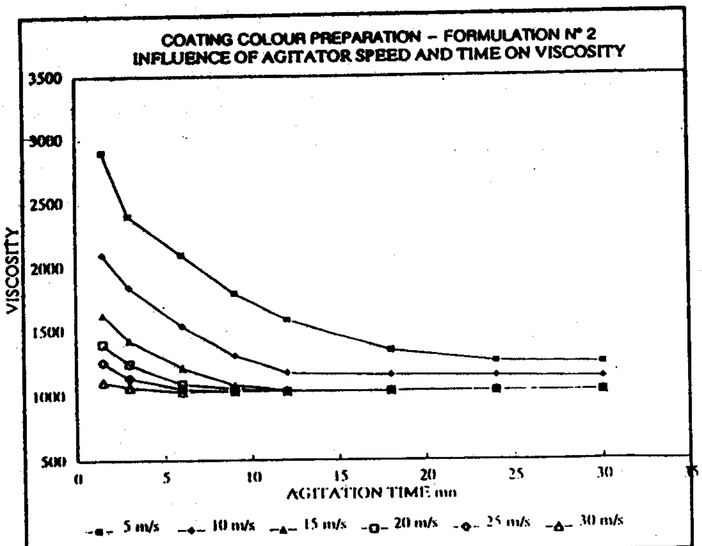
Two examples are reported in the annexed tables A6 and graphs A7-A8; the one difference between the two formulations is the grade of thickener.

INFLUENCE OF SPEED and AGITATION TIME ON VISCOSITY

COATING COLOURS FORMULATIONS (Dry Basis)

RERRERENCE	N01	N02
N01 CLAY	40	40
$CaCO_3$ (GCC 90% 2m)	60	60
C.M.C.L.V.	0.2	0.2
LATEX	10	10
O.B.A.	0.4	0.4
INSOLUBILIZER	0.3	0.3
LUBRICANT	0.5	0.5
NaOH	0.1	0.1
DISPERSANT	0.05	0.05
ANTIFOAM	0.1	0.1
THICKENER A	0.5	0
THICKENER B	0	0.5
% SOLIDS (preparation)	66	66
pH	9.0	9.0





COATING COLOURS PREPARATION

INFLUENCE OF SPEED and AGITATION TIME ON VISCOSITY

COATING FORMULATION N° 2

AGITATOR SPEED m/s	5	5	5	5	5	5
AGITATION TIME mn	6	6	6	30	30	30
% SOLIDS	66	64	62	66	64	62
BROOKFIELD VISCOSITY mPa.S (25°C) 10 RPM	6800	3500	1500	4300	2350	1330
100 RPM	2100	1000	430	1250	.680	380
CAPILARY VISCOSITY mPa.S (25°C) 10 S	380	185	90	350	155	80
10 S	400	210	80	370	150	65
RHEOLOGY TENDENCY Low Shear	P.P	P.P	P.P	P.P	P.P	P.P
High Shear	D	D	P.P	D	P.P	P.P
MAXIMUM COAT WEIGHT WITHOUT DEFECT		10			12	

AGITATOR SPEED m/s	20	20	20	20	20	20
AGITATION TIME mn	6	6	6	30	30	30
% SOLIDS	66	64	62	66	64	62
BROOKFIELD VISCOSITY mPa.S (25°C) 10 RPM	3800	2200	1200	3600	2150	1220
100 RPM	1090	640	360	1030	610	350
CAPILARY VISCOSITY mPa.S (25°C) 10 S	340	150	75	320	145	70
10 S	250	125	60	240	120	60
RHEOLOGY TENDENCY Low Shear	P.P	P.P	P.P	P.P	P.P	P.P
High Shear	P.P	P.P	P.P	P.P	P.P	P.P
MAXIMUM COAT WEIGHT WITHOUT DEFECT		16	→		16	

RHEOLOGY TENDENCY : P.P. = Pseudo-Plastic ; D. = Dilatant.

MAXIMUM COAT WEIGHT = Blade coating – Straight (Stiff) Blade. Angle = 25°. Speed = 800 m/mn

Nr 1 colour The viscosity is almost independant from shear. It is only a little bit higher for very short agitation time at lowest speed.

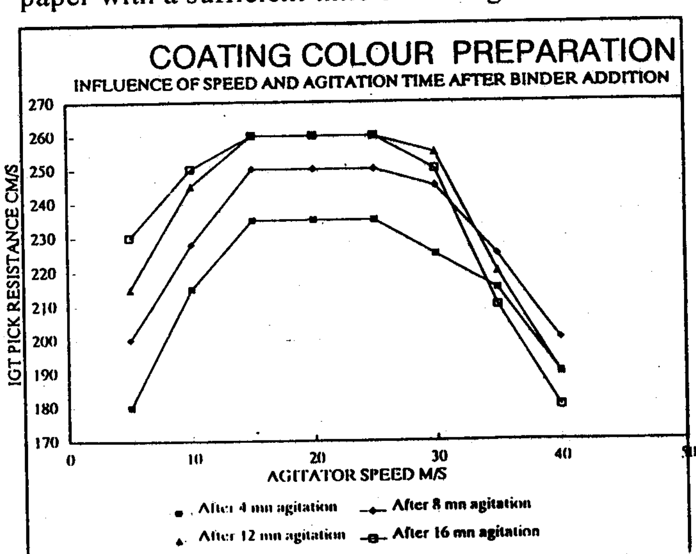
Nr 2 colour The behaviour is quite different of the Nr 1. At low speed, even after 30 mn of agitation, the viscosity is not yet stabilized and remains high. The differences are not only at low shear (brookfield viscosimeter at 10 and 100 rpm) but also at very high shear (capillary viscosimeter in the range of blade coating shear).

In case of low agitation, 5 m/s, the rheology has a tendency to be dilatant (see annexed table A9). The high solids content coating give a surface very rough. For an acceptable aspect, the percentage of solids and viscosity have to be dropped; so the maximum possible coat weight with a smooth aspect is only 12 g/m^2.

With high agitation (20 m/s), the viscosity is quickly stabilized at a lower level. The high shear rheology tendency is in that case pseudo-plastic, much more favourable for application at the blade station. The coated surface aspect is quite good and the coat weight can be raised up to 16 g/m^2 without defect.

Coated paper pick resistance

The shear effect on the mixture pigments-binders is also a critical point. The annexed graph A10 shows an optimum pick resistance of the coated paper with a sufficient time of mixing after addition



of the binders in the pigments slurry in a speed range between 12 and 30 m/s.

We can suppose that in the optimum agitation range, the binder covers uniformly the surface of the pigments. At lower agitation, the binder distribution is not so good with some weak points in the structure. At higher agitation, some pigments particles may also be broken (see the paragraph before) which increase the binder demand; some emulsion breaking can also occur which reduce the binding efficiency of latex.

An optimized colour preparation presents two advantages:

* pick resistance improvement of the coated paper without increase of the binder proportion,
* reduction of binder level for the same pick resistance and consequently a cost saving and an improvement of the coated paper characteristics which are negatively influenced by the binder.

As a conclusion of the viscosity and pick resistance tests results, a two speeds or better, a variable speed mixer is recommended.

The blending at high speed permits a very quick homogenization at full capacity of the mixer and minimizes the risks of "viscosity shocks" with some cobinders (PVA, Protein.....). The high speed is also necessary for the dispersion of auxiliary pigments or the dissolution in the pigments slurry of cobinders added in small quantity in powder form (CMC, protein, cold soluble starch.....) for a very high solids coating.

After addition of the different components, the mixing at low speed, but always in the optimum shear range, permits to obtain the maximum pick resistance and in the same time minimizes some risks of troubles like foam, temperature's increase or emulsions breaking.

FILTRATION - DEAERATION

Some very small quantities of harmful particles in the coating colour can have catastrophic effects: streakes (or scratches) formation at the blade application and more or less free particles on the web which cause defects at the calender, bad aspect and troubles on the printing press.

That harmful particles have different origins:

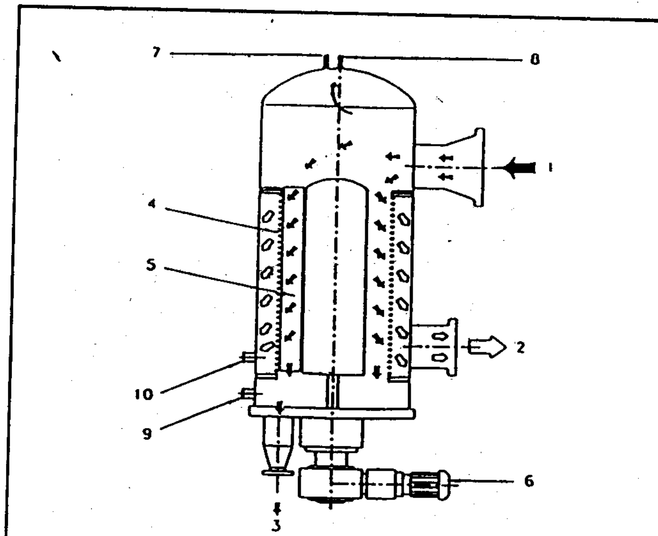
* hard particles remaining in raw materials,
* Dried particles formed all along the preparation and transfer circuits,
* fibrous materials, felt hairs in the return from the coating head.

Another cause of coating troubles is the presence of air:

* foam formation by turbulent flow in the opened parts of the circuits,
* entrapped air on the coating head; the higher the machine speed, the greater the air quantity brought by the web in the colour at the application point.

Depending of the size, the air bubbles lead to colour skipping on the web or craters which give a poor aspect and printing troubles.

A first filtration of the raw materials is generally done before the liquid components mixer. The vibrating screens of the CELCO type proposed by CELLIER are the most efficient for pigments slurries. Very fine screens - commonly 60-80μ - can be



1	Entree du produit	Inlet	Produktzulauf
2	Sortie du produit filtre	Outlet	Auslauf des Filtrats
3	Sortie des rejets	Purge line	Austritt der Rückstände
4	Element filtrant	Filter-screen	Filterelement
5	Râcle	Cleaning blade	Schaber
6	Motoreducteur	Drive unit	Getriebemotor
7	Event	Vent	Belüftung
8	Degazage	Air bleed	Entlüftung
9	Entree eau de lavage	Washdown port	Zulauf des Reinigungswassers
10	Entree eau de lavage par contre courant	Backwash	Wasserzufluss für Gegenstromreinigung

used in order to eliminate all the hard particles which could damage the blade and cause streakes on the coating station.

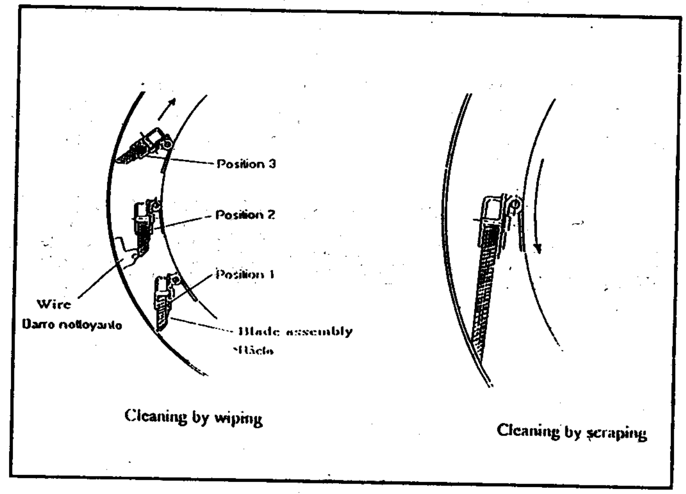
That type of vibrating screen which is very well suited for low flow, is also used with low size opening on the fresh colour just before arrival in the machine supply tank.

For high flow, like the coating head feeding, an other piece of equipment is proposed, the FILTERCEL which is an in-line closed filter equipped with a basket (see annexed sketch A11).

The FILTERCEL has a double function: elimination of harmful particles or impurities and deaeration. At that step of the coating, the harmful particles are mainly coming from the cellulosic web with coating colour excess which is recycled.

Typical advantages of FILTERCEL:
Filtration

- Wide range of slots size, usually 100 to 200μ also less than 100μ if required. But the lower the slot size, the lower the flow through the basket (filtration capacity).
- In/Out flow direction through the basket, so no risk of damaging by high pressure.
- Self cleaning by rotating blades: wipping or scraping (see annexed sketch A12). The harmful particles drop at the bottom of the filter.
- Low pressure drop due to self-cleaning and periodical draining (purge) of the impurities.
- Low pressure drop and triangular wedge wire (slots) avoid fibers extrusion through the slots.
- Very low coating colour loss at every draining (purge).
- Two washing possibilities from inside or outside the basket.
- Very quick and easy accessibility of the filtering basket: opening by spring assisted system and driving motor of the blades located under the filter.



Deaeration

- Separation colour-air by density difference in the filter.
- Permanent air outlet at the top of the filter.
- Deaeration facilitated by the bulged shape cover.

CONCLUSION

The preparation equipments and the working conditions at the different steps of the colour production have main effects on the characteristics of the coating colour itself and consequently on the quality of the coated papers.

These effects depend on the formula; that is why the different pieces of the equipments must be sufficiently polyvalent in order to be able to use the wide range of raw materials proposed for the forseen coated paper grade.

So a thorough knowledge of chemicals and finished products is the first request for the definition of an installation. In that field, the USER and the equipment's MANUFACTURER have complementary experience and their close collaboration is the best chance for a successful project.