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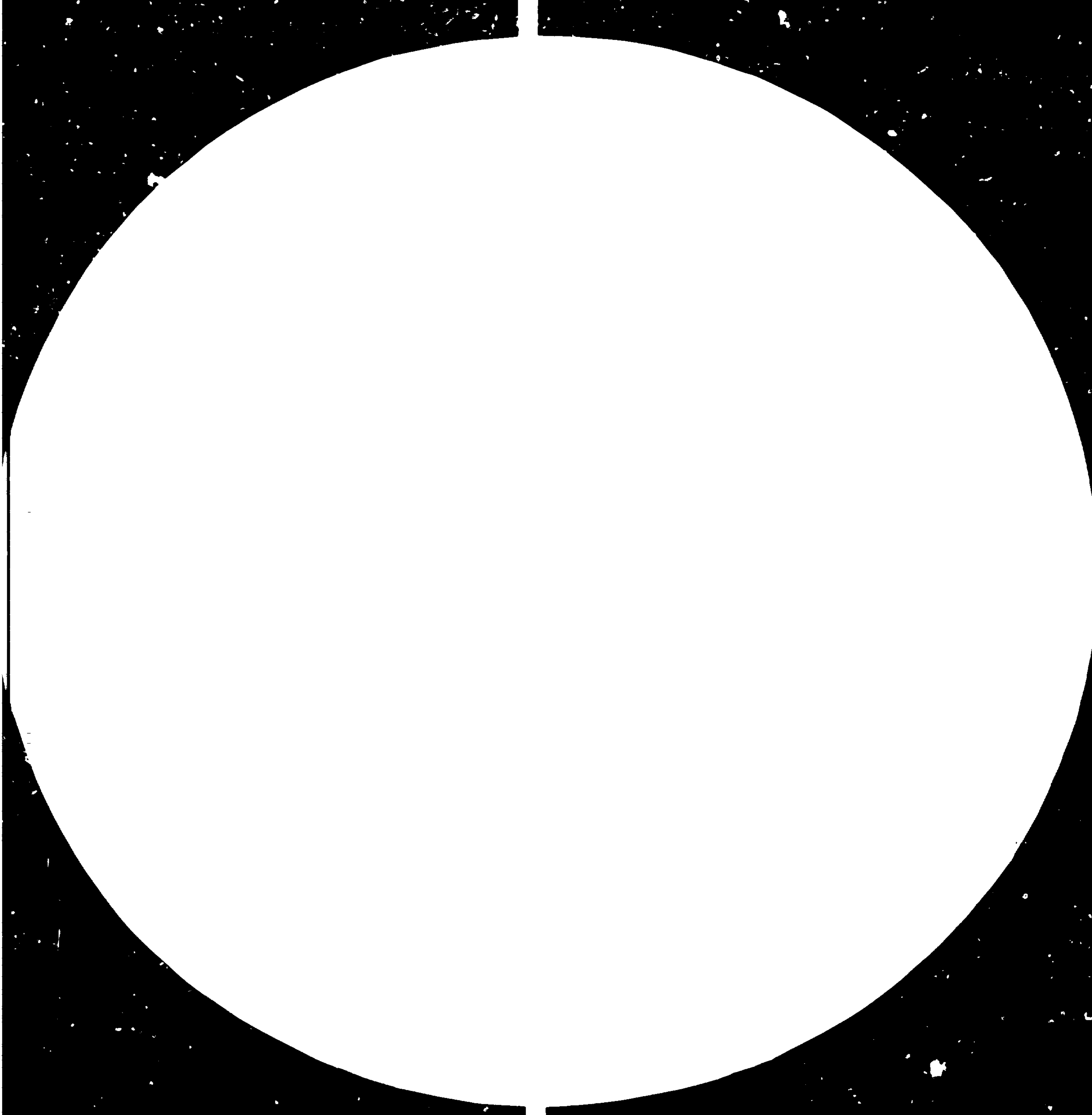


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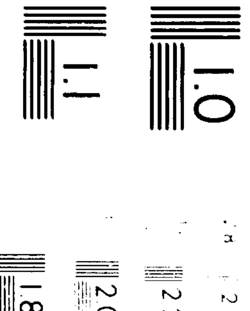
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→ Maria Dietrich

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Manufacture of Washed Kaolin for Paper Industry

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+/ Westbohemian Ceramic Works, Horní Bříza - Kaolin Refining Plant, Kaznějov

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I. INTRODUCTION AND DEFINITION

The term kaolin is applied to a group of hydrated alumosilicates, from the mineralogical point of view, where kaolinite $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$ is the main component. While speaking about an industrially made kaolin in such a case it is a material in which the content of clay minerals is usually higher than 85% the rest being represented by fine particles of quartz, feldspar and other non-plastic minerals.

Kaolin is a white, chemically inert material consisting of very fine particles the sizes of which are ranging from below a micron up to 40 microns. Particles below 2 microns in size are of the shape of elongated, thin, hexagonal plates. (Picture No. 1) Larger plates are of a lamellar structure. It is a white burning material used in the production of fine ceramics and as a filler in the production of paper, rubber, paints, glass fibres and many other products. There is an ample occurrence of kaolin and it is produced in about 60 countries. The world consumption of kaolin has reached beyond 12 million tons per year and 75% of it is covered by the first four producing countries, i.e. the USA, United Kingdom, USSR and Czechoslovakia.

From the geological point of view kaolin deposits may be classified into two fundamental types (Table No. 1).

1. <u>Primary deposits</u> where kaolins had been formed in the same place as the parent rocks through the alteration due to various agents. The primary kaolins show extremely variable composition within a given deposit and in different deposits. The composition of the parent rock

Table No. 1

Comparison of Primary and Sedimentary Kaolins

	Primary kaolins	Sedimentary kaolins
Occurrence	irregular geological formation	beds, lenses, as sediments
Thickness of the deposit	bigger	thinner
Content of kaolinite	lower 10 to 30%	higher 30 to 100%
Variability	very high	high
Particle size	bigger	smaller
Content of non--kaolin clay minerals	lower	higher

as well as the conditions of alteration are factors influencing the clay minerals. Quartz, feldspar and mica in varying amounts are the most abundant non-kaolinitic components of the primary kaolin deposits.

Primary kaolins usually contain 10 to 30% of pure kaolinite. Typical examples of primary deposits are those of Cornwall in England, of Czechoslovakia and of the Federal Republic of Germany.

2. Secondary deposits of kaolin are sedimentary ones and they have been transferred from their place of origin by water, wind, glaciers, etc. and deposited in beds or lenses.

Kaolins from the sedimentary deposits show much higher content of kaolinite which varies from 60 to almost 100% of total. They also are variable in their composition but less than the primary kaolins. Because of the transfer from the place of origin to the actual deposit, particle size of the sedimentary kaolins is much smaller than that of the primary kaolins. The thickness of secondary deposits is usually smaller as these deposits were sedimented. Sedimentary layers of kaolins can be observed. The sedimentation process can be considered as the first step of natural classification and, therefore, sedimentary kaolins are usually more valuable than the primary ones. However, the most usual kaolin deposits are the primary deposits.

The sedimentary kaolin deposits in Georgia and South Carolina in the USA are an exception in the world not only in the extent and mineralogical purity but in the structure and texture of the kaolin itself. High yield of pure kaolin is typical, reaching sometimes up to 100% of raw ore.

Kaolin prices get doubled after about every 10 to 12 years depending on the demand and quality achieved in the dressing and upgrading process.

For the review of the world ex-factory prices of kaolin in terms of £ /pound sterling/ see table No. 2.

Table No. 2

Development of World Ex-factory Prices of Kaolin for Paper Industry

Type of kaolin	Average prices /in pound sterling per ton/ during		
	1961	1968	1975
coating	15 to 21	20 to 26	35 to 37
filling	6 to 10	8 to 14	12 to 19

Definitions

Kaolin is a term that means different things to different people depending upon how and where the term is used.

According to the ASTM (American Society for Testing and Materials), Designation C 242-72, kaolin is defined as a refractory clay consisting essentially of minerals of the kaolin group and which fires to a white or nearly white colour.

According to the Czechoslovak standard No. 72 1540, washed kaolin represents an industrial product gained by a well refining process of suitable decomposed kaolinitic rocks composed from refractory clay minerals with a substantial content of clay minerals, mainly kaolinite, in smaller amounts of dickite and nacrite.

According to another definition, washed kaolin is a white, powdered material with different degree of plasticity depending on the size of crystals and on the admixture of other plastic clay minerals. When fired at 400 to 880°C it looses two molecules of water which changes it into a non-plastic body.

The term China clay is commonly used interchangeably with kaolin and originated from the use of clay, later found to be kaolinitic, in porcelain tableware in China. China clay is more commonly used in the United Kingdom than in the United States and in the Continental Europe.

From the mineralogical point of view, kaolin is the name of a group of hydrated aluminium silicate minerals which include the clay minerals kaolinite, nacrite and dickite. Halloysite is also sometimes added to the group of kaolins.

When the term kaolin is used as an industrial mineral we have to understand a clay consisting of substantially pure kaolinite or related clay minerals which is natural or can be beneficiated by a refining process. Such a clay must, however, reflect the following properties: white or nearly white colour, colour after firing will also be white or nearly white, it is amenable to beneficiation by known methods to make it suitable for use in whiteware, paper, rubber, paint, cosmetics and similar applications; it is also refractory.

Kaolin of bright white colour is the most demanded and the best marketable one. This property is most important for the largest kaolin consumer, i. e. for the paper industry. While almost all kaolin was consumed in ceramic production till 1900 its consumption is only 1/3 of the total production in this branch, nowadays.

The present top technologies in the paper production reach as much as 30% of kaolin furnish into the pulp and, therefore, the paper industry is the largest world consumer of washed kaolins.

The kaolin industry has developed an especially sorted material - coating kaolin - for the surface finish of paper. The surface finish of paper with the application of kaolin caused literally a revolution in the entire printing industry and enabled to cut down dramatically the production cost of coloured picture magazines. Just for illustration about 30 000 tons of coating kaolin were produced in the USA in 1930 whereas as much as 1.8 mill. tons of it were produced there in 1974 and the envisaged figure in the year 2 000 amounts to 5 mill. tons.

Some typical properties of the individual types of kaolin used in the paper industry are shown in table No. 3

The Future

Kaolin is a unique and special non-metallic industrial mineral. It has many industrial applications and sales have maintained a steady growth for over forty years. New applications will continue to be found because its value lies in its white colour, chemical inertness, good flowability, low conductivity of heat and electricity and other properties which hardly can be found in other minerals.

Kaolin, an important industrial mineral, will become even more important in the years to come.

Table No. 3

Typical Properties of Individual Types of Kaolin

for Paper Industry

	Coating kaolin	Filling kaolin
Whiteness, R 457 filter	min. 82% abs.	79% abs.
Rest on 0.0063 mm mesh sieve	max. 0.005%	0.005%
Bigger than 10 microns	0%	5%
Smaller than 2 microns	min. 80%	55%
Abrasivity AT 1000	5 mg	20 mg

II. FUNDAMENTAL FACTORS AFFECTING THE CHOICE OF TECHNOLOGY

The production process of washed kaolin depends on the following basic conditions:

1. Type of a deposit and raw kaolin
2. Required quality to be obtained
3. Labour and energy costs
4. Geographical factor

Generally, it may be said that the majority of good quality ceramic kaolins comes from the primary deposits while the majority of good kaolins for the paper industry comes from the secondary deposits. As long as it is supposed that all the kaolin from a particular deposit will be completely used in the relating ceramic industry the technology will be completely adapted to the customer's requirements.

The paper industry, however, brings much narrower and higher technological limits for the use of kaolins in its blends than the ceramic industry. Therefore, the quality requirements of washed kaolins for paper industries are more defined, strict and the manufacturing equipment of a kaolin washing plant is more sophisticated and the production control must be on a very high level.

Cheaper labour and more expensive energy is Europe resulted in the use of hydrocyclones, filter presses and belt driers whereas in the USA the development tended towards centrifuges, vacuum filters and dust-spray driers.

Transport costs, too, play a substantial role and the transport costs relations between road or railway and sea transport result for instance in competition of kaolin from England in Canada, where it competes with that from the USA or Brasilian kaolin from the deposits at the river Amazona competes with the English one in the Federal Republic of Germany. It is a matter of course that climatic conditions are of great importance in the kaolin extraction, too.

The proper technology must result from laboratory and pilot plant tests which are evaluated scientifically in connection with other economic, market and quality factors.

III. WASHING PROCESS OF KAOLIN

The Czechoslovak technology is quite similar to the English technology and it is practically identical with that applied in kaolin plants in the Federal Republic of Germany. (Picture No. 2)

The raw material is extracted by the open-cast mining method by means of excavators and transported to the crushers in the washing plant by road trucks. The raw material is crushed in hammer crushers to 40 mm maximum grain size and conveyed to blungers by conveyors. A drum blunger separates grains above 16 mm size which are conveyed to hoppers and transported to a dump. Sand remains on the bottom of the blunger and is shifted by means of a worm towards bucket elevator which conveys the sand into a sand washer. Suspension of kaolin, mica and fine sand pours into a basin out of which sand of 0.1 to 1 mm grain size is removed by a bucket elevator. The suspension freed from the greater part of coarse impurities is pumped then into a hydrocyclone of 350 mm diameter. The undersize material from these hydrocyclones is combined with the fine sand from the bucket elevator and pumped for further washing and thickening in the fine-sand dressing plant. The overflow from the 350 mm dia. hydrocyclones is pumped into hydrocyclones of 150 mm diameter. The undersize material from these hydrocyclones is then pumped into setting lagoons. The overflow material from the hydrocyclones is pumped to screens of 64 microns mesh to remove mica. Since the overflow material from the hydrocyclones contains about 80 grams of kaolin per litre the suspension must be thinned before the screening operation. The suspension having been so separated is a medium quality kaolin which is the basis for the production of the coating kaolin. However, for the production of good filling kaolins for the paper industry the suspension must be still separated in hydrocyclones of 50 mm diameter. The overflow from these hydrocyclones is then the filling kaolin of low abrasivity. The undersize from these hydrocyclones is used as filler in the rubber industry. The suspension behind the 50 mm hydrocyclones flows into sedimentation tanks for thickening. To speed up the sedimentation process polyacrylamides are added and the hardness and pH of water are to be adjusted. A concentration of 250 g of kaolin per litre of suspension is achieved in the continuous thickenners and the suspension is pumped into mixing and homogenizing tanks. Giant tanks of 750 cubic metres capacity enable to interrupt the so far continuous production process and get thus time for the determination of qualitative properties of kaolin. Depending on the parameters found out the mixing ratios from the individual tanks are set and charges for the filtration process prepared. Dewatering is carried out in chamber filter presses of specific output of 21 kg per square metre per hour. In such a way kaolin of 27 to 30% moisture content is obtained. This kaolin is either kneaded and made into the shape of noodles for belt driers or made into a suspension of more than 60% of solids in industrial mixers by means of dispersion agents. The belt driers are heated with hot air from heat exchangers and kaolin is dried there to 12% moisture content at the outlet, the heat consumption being 1 100 kcal (4 606 kJ) per kg of evaporated water. For speciel purposes the dried kaolin is further milled and dried to as low as 1% moisture content.

IV. MANUFACTURE OF COATING KAOLIN

Special dressing operations of kaolin take place in the technological section between the thickening and homogenizing processes in the giant tanks. They are the production of coating kaolin and magnetic separation. The fundamental requirements on the coating kaolin quality from the dressing point of view are as follows:

1. Content of particles above 10 microns and below 2 microns
2. High whiteness
3. Low abrasivity
4. Ability to prepare a suspension of high concentration and good fluidity

Coating kaolin produced in the washing plant possesses properties shown in table No. 4.

Picture No. 2 shows the manufacture of coating kaolin.

Kaolin coming from the sedimentation process has about 45 to 55% content of particles below 2 microns and further dressing is necessary to increase this content to 80%. Practically it may be done either by a simple fractionation by sedimentation or by separating it in centrifuges or hydrocyclones.

Table No. 4

Properties of the Czechoslovak Coating Kaolin

Form	Noodles of 10% moisture or 62% suspension
Whiteness, R 457 filter	81% abs.
Portion above 0.063 mm	0.005%
Portion above 10 microns	0%
Portion below 2 microns	80%
Apparent dynamic viscosity	
60% solids Brookfield 100 rpms	31 m Pas
65% solids Brookfield 10 rpms	170 m Pas
65% solids Brookfield 100 rpms	100 m Pas
Concentration for 500 m Pas	71%

The most frequently applied industrial method of the production of coating kaolin is the separation of a concentrated suspension in centrifuges. The producers have chosen this method owing to the good separating efficiency, possibility of simple regulating the separating process and high separating output. The hydrocyclone operation requires comparatively low concentration, separating of the products to increase efficiency and rather high energy consumption per production unit. Hydroseparators with simple sedimentation have comparatively low yield and high investment costs. The product properties in the latter case are rather difficult to be regulated.

When the suspension is to be separated in centrifuges it should be dispersed by adding chemicals, usually polyphosphates or sodium silicates. The separating efficiency can thus be substantially enhanced. Horizontal worm centrifuges of large diameters and about 1 500 revolutions per minute can be installed for the separating process. For example, a horizontal centrifuge the cylindrical part of which being of 1 000 mm diameter with 1 450 revolutions per minute has a working capacity of 8 000 kg of the product per hour at energy consumption of 12 kilowatthours per 1 000 kg of product. The separated coating fraction has a substantially lower concentration while leaving the centrifuge. About 80% of water in suspension entering the centrifuge is discharged along with the coating fraction whereas the coarse fraction is thickened up to 750 g/litre. As long as the entering concentration is high the outgoing coating fraction is so much thickened, too, so as it can be filtered straight. As far as, however, its concentration is low the process of dewatering and thickening by sedimentation is very slow. For this reason there are still thickening centrifuges installed behind the separating centrifuges in the washing plant. For this purpose jet disc centrifuges with a drum of 600 mm diameter and 6 000 revolutions per minute are used. The concentration of the solid phase gets practically tripled after having been processed in the centrifuge. Removal of the portion of particles below 0.5 micron, being the carriers of undesirable colouring admixtures, and improvement of the rheological properties of the product are the favourable side effects of the jet disc centrifuge.

The material is homogenized and mixed in the storage tanks prior to the filtration process. Kaolin having been dewatered in the filter is then kneaded and processed into noodles to be dried in the belt drier. A part of the material is again subjected to blunging to prepare a highly concentrated suspension which will be despatched in the form of a slurry.

On the other hand, a mixture of the kaolin with different additives can be prepared, such as CMC, latex, etc., which support the adhesion of the coating layer to the underlayer.

The mixture shows pH 7 and the viscosity properties, defined according to Brookfield, show

Brookfield viscosity	5 830 m Pas	by 10 rpms
	1 004 m Pas	by 100 rpms

Such a type of coating kaolin can be exported successfully. The majority of paper producers do not usually use one type of kaolin only for paper coating purposes but they combine good properties of several different types. The paper producer has to provide his product still with other properties rendered by the coating. First of all paper must be smooth, lustrous with colour acceptability and adhesivity strength between the coat and underlay. Even these properties can be influenced by kaolin. Substantially more complicated, however, is the influencing of these properties by the kaolin producers.

V. MAGNETIC SEPARATION

Until recently the magnetic separation process was considered to be of a relatively low efficiency due to the very small sizes of kaolin particles and their very low magnetic susceptibility. Only a special design of the magnet circle and the use of fine steel wool as a filter in the magnet chamber have enabled to increase the magnetic gradient by several orders against the classical design and the magnetic separator has thus become effective even in the range of particles the sizes of which are about 1 micron. Picture No. 3 presents the principles of a magnetic separation used in the kaolin industry. The magnetic separation by means of the Sala magnetic separator was performed successfully with the kaolin from Kaznějov in the Pilot Plant of the Research Institute for Ceramics, Refractories and Raw Materials. Following these tests an industrial separator with a chamber diameter of 1 070 mm and a magnetic field of 18 - 22 kilogauss was imported and erected in the Kaznějov Plant.

The separated kaolin in view of a low-abrasivity material contains about 0.6% of Fe_2O_3 and up to 1% of TiO_2. Iron oxides on the surface of a kaolin particle are of different shades starting from yellow up to brown colour causing thus deterioration of the material whiteness. Titanium oxide occurring in the form of anatase causes a cream yellow shade of kaolin due to the high absorption ability of anatase in the violet and blue sections of a spectrum. Hence, removal of these oxides results in an improved whiteness of the material. When the material passes through the magnetic separator the paramagnetic particles are trapped in the steel wool and a chemical analysis of the material which passed through the separator has shown a decreased content of iron oxide by 20% in average and that of titanium oxide by 50%. Though the quantities are absolutely small, i. e. about 6 kg of colouring oxides are removed from 1 000 kg of kaolin, this process results in an absolute increase in material whiteness by 3 to 6%. However, it is a matter of course that the separator cannot do the separation selectively, i. e. to remove the colouring oxides only but it separates all particles the magnetic susceptibility of which is high enough. Therefore, there are material losses amounting to 10%, i. e. 100 kg of kaolin are extracted out of every separated 1 000 kg of kaolin.

The suspension for the magnetic separation must be perfectly dispersed into individual particles. In principle, only such a particle can be separated for which the force of the magnetic field acting on it is stronger than its own kinetic energy. For this reason the materiel proceeds through the chamber filling rather slowly, at a velocity of 6 mm per second. The time of the passage of the material through the chamber is given by the saturation of the filler surface with particles and this is called a load of the filler. When the intensity of the magnetic field is 18 - 22 kilogauss the process is performed under the filler load of 2 grams per 1 cubic centimetre of its space. Any higher intensity of the field may probably enable to increase the filler load and higher speed of materiel passage through the chamber.

VI. OTHER REFINING PROCESSES

Aside from the particle and magnetic separations which are the most common methods in the kaolin industry to manufacture kaolin for paper making, some other processing methods can be applied in order to increase the quality of kaolins produced.

Delamination of kaolin stacks is industrially applied by splitting apart the larger books or stacks of kaolin. This yields a product in which the individual plates tend to be wider, thinner and whiter. The manufacturing process used for the delamination includes wet attrition grinding and extrusion. Delaminated kaolin has special application in light-weight paper coatings.

Calcination is another widely used process to produce special products from kaolin. When kaolin is heated to approximately 800 - 1 000°C kaolinite is converted to metakaolinite while some presence of mullite and cristobalite can be noted. Such calcined kaolin is whiter, brighter and has better properties when used and is more abrasive.

Chemical bleaching is the process in which colouring oxides, such as Fe_2O_3 and TiO_2, are converted into modifications with lower colouring effects and/or are diluted and washed out from the kaolin slurry.

Other special processes are used to modify the surface of the kaolin chemically to improve its function in many systems. These surface-modified kaolins can be hydrophilic, hydrophobic, organophilic, etc. The paper industry has not yet paid too much attention to surface-modified kaolins.

VII. COMPARISONS OF TECHNOLOGIES IN THE USA, ENGLAND AND CZECHOSLOVAKIA

Any exhaustive comparison of main technologies in different continents is complicated as natural and economic conditions have influenced the applied technology very much. Picture No. 4 shows different dewatering technologies applied in different kaolin refining plants.

1. Extraction

First differences between the dressing methods may be found as early as in the open-cast mine. The first stage of dressing is mostly done straight in the mine while the plant proper is usually quite far in England and in the USA. Extraction in England is made by means of monitors while in the USA and Czechoslovakia it is done by excavators. The raw material blunged by the water spray with a comparatively low concentration of solid matters is freed from sand in spiral separators, hydrocyclones or hydroseparators and having the concentration of 5% by weight this imperfectly separated suspension is pumped into giant, as large as 5 000 cu.m tanks, in which it is thickened after flocculation. In the USA as much as 30% suspension is made by adding a dispersion agent. The suspension is freed from coarse particles in rake or drum separators as early as in the mine. Hence, the suspension comes out from the mine in the USA and

England while raw material comes from the mine in Czechoslovakia for further processing. There exist cases when slurry is pumped from the mine as far as to the washing plant at the distance of 26 kilometres under the following parameters:

Pipeline diameter	203 mm
Pump head	16 m
Rate of flow	2 200 l/min.
Slurry concentration	37% by weight
Pump input	225 kW

2. Separating plant

Thickened slurry from the giant tanks in England is dispersed and separated by hydroseparators whereby kaolin for filling and ceramic purposes is obtained. Coating kaolin is separated and thickened in centrifuges. Before the filtering process takes place all the material is collected in mixing and storage tanks to ensure a constant quality.

Highly concentrated slurry in the USA is supplied from the mine to the separating plant in an already dispersed state and there it is blended with material from other mines in homogenizing tanks where the separation of coarse portions takes place at the same time. Centrifuges are used in the next separation stage even for the production of kaolins for filling and ceramic purposes.

The quality of kaolins for filling and ceramic purposes in the Kaznějov washing plant is achieved by separating a suspension of low concentration in hydrocyclones while the separated portions only are thickened.

3. Dewatering and drying

Pressure filtration process in chamber filter presses is almost exlusively used in England and in Czechoslovakia. Vacuum drum filters are used in the USA. Drying takes place in belt driers and most of the material is dried in dust spray driers in the USA.

The sequence of the production operations from the point of view of flocculation and dispersion may briefly be illustrated as follows:

USA - all the material is kept in dispersed state from blungers up to the separating centrifuges. All the material for filtration is flocculated afterwards and then dispersed again to be ready for the dust-spray drying and despatch in the form of a concentrated suspension.

England - after the coarse portion has been sorted out all the material is flocculated to be thickened in the giant tanks and then dispersed for the hydroseparators and separating centrifuges.

It is followed by flocculation for the filtration process and a part of the material is dewatered and then dispersed to be ready for despatch as a concentrated suspension or for the dust-spray drying.

Czechoslovakia - when the material has been separated in the hydrocyclones at a low concentration all the material is flocculated for thickening. A part of the material is then dispersed for the centrifuges and for the magnetic separation; it is followed by flocculation again and by filtration. A part of the material is deflocculated again to be ready for despatch in the form of a concentrated suspension.

VIII. QUALITY CONTROL AND MANAGEMENT

A. Quality control

The very broad range of kaolin use starting from ceramic products up to the paper production or as a catalyst in the cracking process of crude oil has led to as much as distressing number of tests and quality controls. The modern plant laboratories employ nowadays more people than the kaolin separation plant itself. The information on quality is obtained in total from 7 places of the refining process. (Picture No. 5)

1. Geological exploration

That is performed well in advance of the extraction and it determines the direction of extraction for a long period. It is made on contractual basis and the results of this exploration are supplied in the form of the following classification shown in table No. 5.

2. Detail geological exploration

That is usually performed by the kaolin plant own drilling equipment and it supplements the comparatively rough network of the basic exploration. It is carried out short before the extraction and the results are evaluated in the plant laboratory. Its purpose is to detect any deviations in the stratification and to set more accurately further direction of extraction of kaolin of a certain quality.

Table No. 5

Classification of Geological Reserves

Stage of geological work	Category of reserves	English equivalent of categories	Scale
1.Prospecting	D_2	geol. probable	regional 1:100 000 to 1:50 000
	D_1	geol. expected geol. possible	to 1:20 000
	C_2	geol. estimated	1:20 000 to 1:5 000
2.Exploration	C_1	industrial possible	detailed 1:5 000 to 1:1 000
	B	industrial proved	1:1 000
3.Mining exploration	A	for mining purposes	industrial 1:1 000 to 1:500 /in special cases also 1:200/

3. Spot samples of the raw material being extracted. These samples enable to determine the storage place for the extracted material in compliance with its quality in the homogenization stock yard.

4. Samples taken at the separation process. These samples taken after the separation process serve the purpose of verification of correct function of the individual dressing stages and correct blending ratio of the material from the indidividual homogenizing tanks.

5. Samples of the thickened slurry from the homogenizing tanks. The samples give the background information for the determination of blending ratios between the individual tanks for optimum utilization of the raw material.

6. Inspection dry samples before the entrance into the despatch storage bins. These samples should verify the correctly determined blending proportions from the individual tanks. They furnish the last information on the quality before the material is put into the storage bins of the despatch department.

7. Samples of material being despatched. These samples are kept in a custody for possible later analyses. The samples are used for the elaboration of a test certificate of the despatched goods.

In principle, the laboratory has to give background data for the decision-making of the managerial staff as well as to verify the correctness of their decisions. This complex system of quality control is ensured by respective technologists in the individual manufacturing sections who receive the information data concerning their department. All the results from the laboratory are concentrated at the production manager who evaluates the correctness of decisions made by his subordinate technologists.

B. Laboratory tests

In principle, these tests may be specified as basic ones, i. e. those which must be carried out at every type of material regardless its use, and special ones being connected with the use of kaolin directly.

a) Basic tests

These tests are to verify the degree of separating of the material.

1. Rest on 0.2 mm mesh sieve

The size of the rest on this sieve gives a signal that the material has been additionally impurified during its transit from the individual technological operations. The value of it at good kaolins should be expressed in terms of ten-thousandths of a per cent.

2. Rest on 0.063 mm mesh sieve

The size of the rest on this sieve gives an information on the quality of the separation process. The value of it at good kaolins should be expressed in terms of thousandths of per cent.

b) Special tests

1. Whiteness

According to the recommendation by the ISO the whiteness is tested by the ELREPHO instrument using R 457 filter. It is expressed in terms of percentage of absolute whiteness. This value is a decisive property for the application of kaolins in the paper industry.

2. Abrasivity

For the abrasivity test the AT 1000 EINLEHNER instrument is applied. This is decisive property for paper kaolins, too.

3. Moisture content

Moisture content is a decisive property for rubber kaolins and for the production of glass fibres. There are admissible ranges defined for kaolins applied in the paper industry.

4. Content of impurities detrimental to rubber production (poisons).

It concerns the content of Fe, Mn, Cu in an extract of nitric acid. It is a decisive property for the production of rubber and cables. The laboratories use different atomic spectrometers.

5. Chemical composition

Content of oxides of the following elements: Al, Si, Ti, Fe, Ca, Mg, Na, K, Pb, Cd. These analyses are important for the production of glass fibres and for the ceramic industry. Again, different types of spectrometers are used to determine the content of different oxides in the kaolin.

6. Particle size within micron ranges

It gives a more accurate view on the separating efficiency of the individual operations. Particle size is the decisive property for the paper coating kaolins. The laboratory can use the SEDIGRAPH 5000 D instrument.

7. Fluorine content

It is a decisive property for the glass fibres producers and for the ceramic industry. The laboratories can use the ORION 901 instrument.

8. Viscosity

It is a decisive property for customers who buy paper coating kaolin and for the casting processes in the ceramic industry. The laboratories can use the BROOKFIELD instrument.

9. Tests required by the ceramic industry

These are first of all tests of refractoriness, whiteness after firing, drying and firing shrinkage, green strength and firing strength, castability, water absorption and volume weight after firing. These tests are made using the equipment of a ceramic laboratory.

It is a matter of course that it is impossible to make all these tests in all the 7 stages of the quality control. It is necessary to understand the mutual dependence among the results of different tests and kaolin properties at its different applications and to understand the way how to influence the resulting properties during blending or during its further dressing. There exist some correlations of properties. For instance kaolin with a low content of particles below 2 microns will possess higher abrasivity and lower whiteness. On the other hand, however, two types of kaolins of identical degree of separation from different spots of a deposit do not usually show identical abrasivity. The correlations of properties found out in one deposit usually cannot be applied to another deposit without any dressing. Recipes for the blending of individual types of kaolins are always made rather on the basis of experience gained from the previous practical experiments than on an exact mathematical basis. In many cases the kaolin properties are those derived from several basic properties while the influence of these basic properties on the derived ones has not yet been even known.

This statement, however, should not spur on a return to empiricism but it should initiate further and more profound study of the basic properties of kaolin and their influence on final properties of a product. Ever broader scope of the kaolin use has multiplied the demands on the quality control and instrument equipment as well as manning of the laboratories.

IX. SUMMARY

More than hundred-year tradition of production and large reserves of high quality raw material provided conditions for the commissioning of the modern kaolin washing plant at Kaznějov in 1974; the plant capacity is over 250 000 tons of washed kaolin per year. This plant is the largest kaolin washing plant in the European Continent.

This paper should illustrate the reasons leading to the choice of the technology applied in this plant and to compare it with the technology employed by the largest producers in the USA and England. A part of this paper deals with the quality control and the applied laboratory technique.

In order to support the development of kaolin washing technology in developing and least developed countries, this paper makes a cross-section through all problems related to the application of kaolin in the paper industry.

X. LIST OF TABLES

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XII. REFERENCES

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