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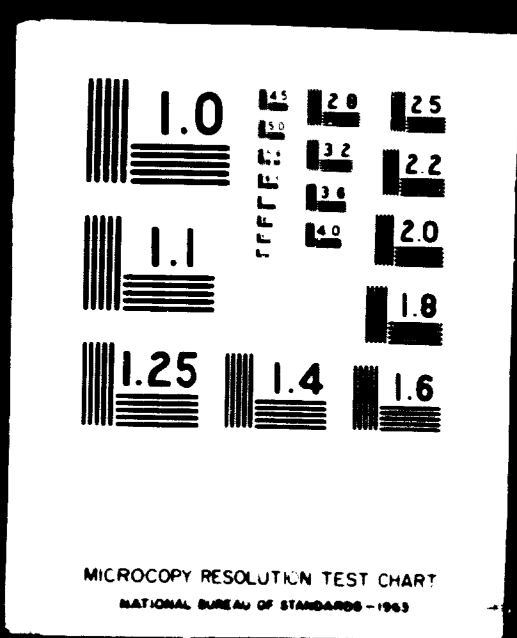
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Materials Industries in Africa

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TECHNOLOGY OF CLAY BUILDING MATERIALS MANUFACTURING[1]

by

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We regret that some of the pages in the microfiche copy of this report may not be up to the proper legibility standards, even though the best possible copy was used for preparing the master fiche.

The brief data about the clay wall building materials, which are being manufactured in the USSR, are represented in this paper. The paper touches upon evaluation of the raw materials for the manufacturing of clay building products; classification and characteristics of clays are also cited. Some features of clay wall materials producing technology are described, including two-ply ceramic products. All of this is based on the practical experience of the Soviet building materials industrial enterprises as well as the Soviet scientific-research Institutes.

In this paper the data of the rewiew of modern state and some guidelines for the future of building materials manufacturing in the countries of West-, East- and Central Africa, reported by I.Horvath, the technical adviser of the Interregional Seminar on the Development of Clay Building Materials Industries in Developing Countries (Denmark, August 1968), in his paper "The clay and ceramic industry in Africa" were taken into account.

Due to shortage of information in national resourses of raw materials in a number of African countries and the necessity to research and test clay materials of these countries this paper includes raw materials qualitative evaluation. The information reported at the abovementioned Seminar by the participants from Marocco, Sudan, Ethiopia, Ghana, Somali and UAR, which concerns the state of clay building materials industries in their countbies, was also taken into consideration.

The recommendations of Industrial Technology Devision of UNIDO sent alongside with the letter and the memorandum TS 431/2 (12) of 24 July 1970 to the State Committee for Science and Technology of the Council of Ministers of the USSR were taken into account and producing technology and application of hollow ceramics. Special attention is devoted to qualitative evaluation of raw materials for the manufacture of ceramic wall building materials.

In accordance with the request of UNIDO this paper is presented in Russian and English, each in duplicate, with the summary, as a supplement to those sent before.

I. Brief Review of the State of Clay Building Materials Manufacturing in the USSR.

In the Soviet Union the enterprizes producing wall building materials share one-fifth of the capital production funds in the national industry of building materials. The nomenclature and assortment of wall building materials differ with the geological, natural and climatic conditions in various regions of the country so that their choice depends upon the availability of this or that raw material resources in the construction area, upon the development level of the building materials industry in a given region, upon the type of houses to be constructed and upon economic expediency of the use of certain types of products.

In the total output of wall building materials a considerable place is taken up by the production of clay brick and other heavy building ceramics which is a large branch of the Building Materials Industry. The output of clay brick totalls more than 30 milliard comparison bricks which is about 60% the total wall building material production. The manufacture of clay brick is concentrated, mainly, at mechanized plants with outputs from 25 to 50 million comparison bricks annually and at major industrial centres - at plants with outputs from 100 to 200 million comparison bricks annually.

A wide range of clay products, such as clay brick, hollow brick and ceramic stones, facing ceramic tiles, large brick blocks, internal and external brick wall panels produced by vibration method, wall panels of hollow ceramic stones, are being produced in the country. Clay wall building materials are made for manual brick laying and for the production of large wall blocks and panels for internal and external walling.

The State Standards (GOST) determine the technical requirements on the raw materials and on the finished products as well as test methods and conditions of storage and haulage. To set up definite indices for the raw materials, technical requirements on the raw materials are worked out.

The common clay brick is devided into two types: standard brick measuring 250x120x65 mm and modular brick measuring 250x120x88 mm with technological perforations and weight not over 4 kg. Compressive and bending strength, water absorbtion, resistance to freezing and aestetic properties are the qualitative characteristics of the brick. Mechanical characteristics of solid and hollow bricks, depending on ultimate compressive and bending strenght, and those of hollow stones, depending on ultimate compressive strenght, have to meet the requirements of 300, 250, 200, 150, 125, 100 and 75 kg/cm^2.

The set up permissible dimensions are: for common (comparison) solid and hollow brick - (250±6)x(120±4)x(65±3) mm; for hollow stones - (250±6)x(120±4)x(138±4) mm; for facing brick - (250±4)x(120±3)x(65+3 and -2) mm; for facing stones - (250±4)x x(120±3)x(140±3) mm.

For facing facades of buildings and inner hall walls, staircase walls, etc., ceramic facing brick and stones are used which are layed simultaneously with wall laying as structural and facing articles.

These articles have two adjacent surfaces - binder and stretcher surfaces, which can be smooth, raised or textured. The face surface can be textured by mineral fines by means of gunitting, engobing and trimmed with rollers. There is also a method of moulding two-ply products consisting of brickbody and face layer.

Ceramic facade tiles of semi-dry pressing are widely used for external facing of buildings. These tiles can be glazed or unglazed (smooth or raised). A ceramic wall panel measuring 3.18x2.77x0.38 m is a widespread kind of wall panel for external walls of five-storeyed dwellings and for the top fourth and fifth floors of many-storeyed buildings. Such panels are usually assembled of hollow ceramic stones. Large wall blocks of brick are also used in the construction of residential houses. The dimensions of such blocks are: length - up to 2.8 m, height - up to 2.65 m, thickness - 1.5 m, 2 and 2.5 bricks.

II. Raw materials.

Raw materials for brickmaking are low-melted clay and loem clay, which are natural mixtures of the clay minerals (kaolinite, montmorillonite, etc.) with quartz sand. Low-melting clays of average or moderate plasticity are used for hollow stones and blocks, refractory clays of low- and average temperature of sintering find application in manufacturing of face ceramics as well as low-melting clays sintering to a uniformly coloured bodies.

In accordance with Soviet practice raw clay materials for ceramic industry are classified as follows:

Table

Indication	Classes and groups of raw materials	Indexes
1	2	3
1. Refractoriness	Refractory clay	above 1580°C
	High-temperature clay	from 1350 to 1580°C
	Low-melting clay	less than 1350°C
2. Content of Al_2O_3+TiO_2 in the sample of ignite clay	High basic clay	above 40%
	Basic clay	from 30 to 40%
	Semiacidic clay	from 15 to 30%
	Acidic clay	less than 15%
3. Sintering ability		Not less than in two points, temperature range being 50°, without any signs of overburning. Waterabsorbtion:
a) rate	High	not more than 2%
	Average	not more than 5%
	Non sintered	more than 5%
b) sintering temperature	Low	less than 1100°C
	Average	above 1100 to 1300°C
	High	above 1300°C
4. Dyeing content in the sample of ignite clay	Very low	Fe_2O_3+TiO_2 up to 1%
	Low	Fe_2O_3 - less than 1,5%
		TiO_2 less than 1%

1	2	3
	Average	Fe_2O_3 from 1,5 to 3% TiO_2 from 1 to 2%
	High	Fe_2O_3 more than 3% TiO_2 more than 2%

Note: Clays in high and average dyeing oxides are evaluated in accordance with uniform colour of burnt product.

5. Plasticity	High plastic clay	Plasticity more than 25
	Average plastic clay	from 15 to 25
	Moderate plastic clay	from 7 to 13
	Low plastic clay	less than 7
	Non-plastic clay	no plastic dough
6. Fine dispersity size distribution	High dispersive	Particles size: less than 10 mu - more than 85% less than 1 mu - more than 60%
	Dispersive	less than 10 mu - from 40 to 85% less than 1 mu - from 20 to 60%
		less than 10 mu - less than 40%
	Coarse dispersive	less than 1 mu - less than 20%
7. Coarse-grained impurities content		
a) quantity of impurities	Small	Size of impurities more than 0,5 mm - not more than 1%

1	2	3
	Average	from 1 to 5%
	Lafge	more than 5%
b) size of impurities	Small	Prevalent impurities size less than 2 mm
	Average	from 2 to 5 mm
	Large	more than 5 mm
c) type of impurities	Quarts impurities	quarts sand, quarts, quartzite, pieces of silica rocks etc.
	Iron impurities	pyrite, limonite, feric hydrated oxides etc.
	Carbonate impurities	calcite, dolomite etc.
	Gypseous impurities	gypsum
	Organic impurities	vegetable remains, peat, coal etc.

Laboratory tests for raw materials for brick, hollow stones and ceramic facing tiles:

1. Presence, quantity and size of coarse-grained impurities.
2. Presence, quantity and size of lime impurities.
3. Plasticity.
4. Sensitivity to drying.
5. Dry shrinkage.
6. Sintering and melting temperature.

The content of SiO_2, $Al_2O_3 + Fe_2O_3$, TiO_2, CaO, MgO and ignition losses are determined by chemical analysis of clays for bricks and hollow stones manufacturing.

Classification of a raw material according to its particle size is one of the most important steps in ceramic processing.

Grinding analysis are suitable for raw material high in quartz sand. The clay should be separated into fractions or particle size groupings of the clay and non-clay components:

large sand particles	- more than 1 mm,
average sand particles	- from 1 to 0,25 mm,
small sand particles	- from 0,25 to 0,05 mm,
powdery particles	- from 0,05 to 0,01 mm,
powdery particles	- from 0,01 to 0,005 mm,
clay particles	- less than 0,005 mm.

The content of clay particles less than 0,005 mm is a very important feature of clay properties for the manufacture of ceramic building materials.

Wet sieve analysis are suitable for dispersive clay grain size distribution. Clay should be separated into following fractions:

large sand particles	- more than 0,5 mm,
average sand particles	- from 0,5 to 0,20 mm,
small sand particles	- from 0,20 to 0,05 mm,
powdery large particles	- from 0,05 to 0,01 mm,
powdery small particles	- from 0,01 to 0,005 mm,
clay particles	- less 0,005 mm.

The physical properties such as natural water content, combined water, swelling, maximum shearing stress are determined. Determination of refractoriness for refractory clays should be imperative.

Based on the results of laboratory tests the recommendations for further batch clay testing are suggested. The batch clay tests include choice of suitable clay mix, determination of processing parameters and testing of finished products, i.e. dry and firing shrinkage, water absorbtion, volume weight (for hollow stones), compressive and bending strength, resistance to freezing and thawing etc.

The batch clay tests permit the conclusions of raw material fitness and the recommendations on technological production schemes, regimes of clay preparation and moulding, drying and firing of products to be made.

III. Manufacturing Technology.

Contemporary technology of producing clay building materials is based on three principally different production schemes:

1. Plastic method.
2. Semi-dry or dry press.
3. Casting.

The most widely spread is the plastic moulding by the column-producing auger presses. The classic flow sheet consists of winning the raw materials in the quarry, clay processing and preparation of clay mix (with grogs, burning-out and other additives) in wet pans, rools and clay mixers product moulding by auger presses, drying of the product under natural or artificial conditions and firing in tunnel or circular kilns.

Frequently the technology of producing ceramic articles requires various grog additives to be introduced into the clay mix to improve drying and other properties of raw materials. Depending on their purpose, the clay additives are divided into: non-plastic; non-plastic and fully or partially burning-out at the same time; burning-out; beneficiating and plasticizing. As grog additives sand, sandy clays, chamotte and other mineral additives are used. Dehydrated clay obtained by means of firing at a temperature of 600-800°C is an effective grog additive. Depending on the machinery used (rotary kiln, sintering furnace, fluidized bed furnace, etc.), the time of heat treatment of clay is some 4-5 to 60 minutes. The degree of clay dehydratation is characterised by the uniformity of firing, complete loss of plasticity and slight swelling.

Sintering in fluidised bed based on direct interaction of gases and ground hard particles of clay should be considered a more improved way of obtaining dehydrated clay. It involves an intensive mixing of small-size material particles, a developed contact surface between gases and clay is obtainable along with practically the same sintering temperature and material concentration by the entire bed volume.

The addition of dehydrated clay to the clay mix reduces considerably the sensitivity of the adobe to drying which permits reduction of product drying and firing time with simultaneous increase of product quality. The introduction of dehydrated clay is especially effective with raw materials requiring more than 15% grog addition.

Sawdust, peat, carbons, slags, ashes from thermal power stations, etc. are used as non-plastic and burning-out additives; anthracites, cokes and other kinds of high heat value fuels are used as burning-out additives. As plasticizing additives highly plastic clays, bentonite, etc. are used.

For clay winning such machines as multi-bucket, single-bucket and rotary excavators are used. The overburden is removed by various means: excavation and lorry haulage, removal by bulldozers and scrapers, by washway and transportation by hydraulic facilities, etc.

Choice of mechanisms for the processing of raw materials depends on the kind of the raw material, the nature of treatment and degree to which it is to be processed as well as on the kind of product to be manufactured.

The products are dried in natural (drying sheds) or artificial dryers (chamber and tunnel dryers).

It is our opinion that the most effective artificial dryers are the tunnel dryers with counter-flow of the drying agent.

The products are fired in continuous circular or tunnel kilns. More effective are tunnel kilns 80 to 120 m long. When the enterprise is not large the firing can take place in periodic kilns of a simplified design. In that case fuel consumption is two-three times higher than in the continuous kilns.

For drying and firing gas, liquid and solid fuels are used. Transportation of the products on pallets or containers as unit loads is also very economical. Prefabricated wall panels and large brickwork blocks are transported by panel carries and specially equipped lorries with trailers.

1. Brick.

The clay is won by single-bucket excavators with outputs from 16 to 48 cu.m per hour. In case of layered deposition of different clays in the quarry multi-bucket excavators with outputs from 18 to 48 cu.m per hour are used, there are also excavators capable of producing up to 70 cu.m per hour.

Large enterprizes employ rotary excavators with outputs up to 200 cu.m per hour.

To improve the quality of the raw material natural weathering of clays in storage piles and pits is practiced; sometime the material is re-won and weathered. Use is also made of clay stores in which the clays and processed clay mix are maturing.

In the USSR raw materials are processed by the following equipment:

Machinery	Output
1	2
1. Clay rippers	up to 25 cu.m per hour
2. Box feeders	from 15 to 35 cu.m per hour
3. Hammer mills, single and double rotary	from 12 to 20 cu.m per hour

1	2
4. Stone separating rolls	20 cu.m per hour
5. Rough milling rolls	up to 35 cu.m per hour
6. Fine milling rolls	18-20 cu.m per hour
7. Perforated rolls	20-25 cu.m per hour
8. Pug mills	4-6 cu.m per hour
9. Clay mixers, double-roller common and with steam tempering (steaming up to 35-50°C)	from 18 to 35 cu.m per hour
10. Wet pans	13 and 18 cu.m per hour
11. Column presses (auger)	from 2 to 5 thous. pcs/h (brick size 250x120x65 mm)
12. Vacuum presses	from 5 to 8 thous. pcs/h
13. Semi-dry presses	from 2,5 to 5 thous. pcs/h

Depending on the raw material, the drying time in the chamber dryers is 30 to 80 hours and more, in tunnel dryers - from 12 to 48 hours.

The firing time in the circular kilns is 48 to 84 hours, in tunnel kilns - 70 to 100 hours. Introduced into the clay bulk as burning-out additives are some 50 to 80% of fuel necessary for the firing (coal, sawdust, etc.).

2. Hollow Brick and Clay Stones

Hollow stones are made of high and average plastic clays. The clay mix is prepared in the usual technological process employed for the solid brick in which the same equipment and the same quantities are used which ensures high-quality processing of the raw materials. Frequently the clay mix is allowed an intermediate weathering.

The product is moulded in vacuum presses. Their drying takes place in common tunnel and chamber dryers, firing in circular and tunnel kilns.

The volumetric gross weight dried to constant weight is as follows:

1. For brick of class A up to 1300 kg/m^3
2. For brick of class B from 1300 to 1450 kg/m^3
3. For clay stones - not more than 1400 kg/m^3

The number, size and shape of perforations depend on the properties of raw material, technological equipment, requirements on heat conductivity of finished product, etc. The use of perforated building materials is very effective from the point of view of heat insulating properties of the products, in reduction of wall thickness by 20-25% and the weight of walls by 30-35% for the moderate climatic conditions of the USSR; it is also cost saving in transportation, etc.

In the semi-dry pressed brick the volumetric weight is up to 1500 kg/m^3, the perforations being through and dead-end ones.

3. Ceramic Facing Products

Along with the production of common ceramic facing materials there are a number of methods by means of which coloured-texture ceramic wares can be obtained, e.g., guniting, engobing, glazing, etc.

To obtain facing products by guniting involves texturing of the face surfaces of the clay column issuing from the extruder with mineral fines (crushed sandstone, grog, glass, ceramic fines, sand, etc.). The mineral fines are applied under pressure of 2-3.5 atm.; this can be followed by imbedding of the fines and surface smoothing with rollers. Recommended size of the fines from 0.5 to 3 mm. The method of guniting is simple and cost-saving.

Engobing of the products involves application of a coat of engobe 0.3 to 3.5 mm thick to the face surfaces. The engobe can be prepared from various clays with additions of sand, glass fines, etc., and pigments There are various engobing techniques: application of the engobe to the surfaces of the clay column under pressure; pulverization of freshly moulded or dried adobe; dipping of the adobe, etc. The basic requirements on the engobes are their durable adhesion to the article dependent on a number of factors, one of them being - the same thermal expansion factors of the engobe layer and the product body.

4. Two-ply ceramic products

In some areas a good economic effect is obtained by the use of two-ply ceramics (two-ply brick and stone) as structural and facing material. In accordance with the standards and technical requirements (GOST 7484-69) the two-ply products are facing materials and can be solid or hollow, their compressive strength being from 300 to 75 kg/cm^2 ; water absorbtion of brickbody from 6 to 14 per cent and of face layer not over 12 per cent. If carbonite clays are used for brickbody, water absorbtion may be somewhat higher and is determined experimentally.

The technology of two-ply ceramics manufacturing has been elaborated in 1948 and is successfully used in many areas of the country. A special machine "CM-1173" with batching and synchronizing devices for moulding two-ply ceramics is used nowadays in the USSR.

Clays commonly used for brickmaking may be utilized as a raw material for two-ply ceramics. Clays burning to various and uniform shades of white, orange, pink, cream, etc., are used for face layer. The refractory clays (monotermite and caolinite) are used when light shades are to be obtained. The manufacturing of 1000 bricks requires only 0.1-0.2 m^2 of these clays.

<u>The brickbody.</u> The raw materials have to be free of rocky and carbonate impurities and with minimum soluble salts content. Alkali metals sulphate and magnesium sulphate content should not exceed 0.2 per cent and calcium sulphate content should not exceed 0.7 per cent after firing.

Various schemes of preparation depend on the quality of raw materials. The technological scheme has to provide uniformity of clay mix (in case of multi-component charge), crushing and removal of impurities; uniform distribution of water throughout the clay and constant feed to the extruder. The intermediate weathering is also advisable. Depending on local conditions and equipment available, technological schemes may differ but the principal requirement on preparation of quality clay mix must be met.

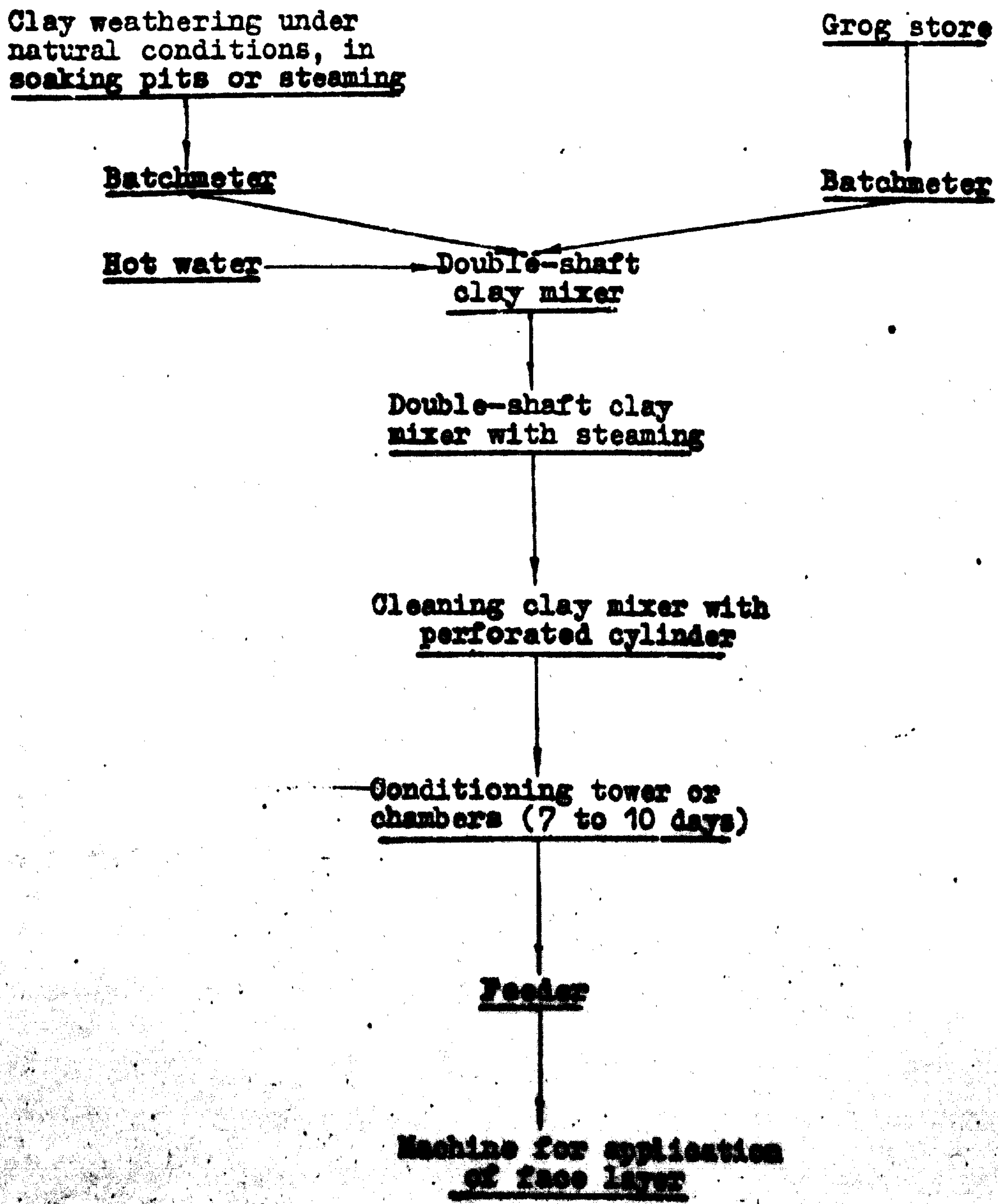
For loessial clays conventional technology of mix preparation is used, as it is for the brick, except that the mix is allowed an intermediate weathering. For readily-soaking raw materials or weathered clays which have moisture content approximating that required for moulding a simplified processing scheme is used. For difficultly soaking raw materials wet pans and pug mills are used. For schistose stone-like clays with stony inclusions desintegrating rolls, drying drums and rotary mills could be recommended. In all cases an intermediate clay weathering is desirable.

Face layer. To get the face layer various plastic clays with good shaping properties and burning to uniform colours are utilized. Quartz sand, chamotte and some crushed minerals: perlite, liparite, nephelite and others are used as grog. Scrap glass, silica-fluoric natrium, pieces of silica are used as flux.

The texture and moisture of clay for face layer have to be uniform, of definite consistency with the clay minerals being completely hydrated. The clay preparation and processing being carefully performed, these properties will be achieved.

The clay mix is prepared by one of three methods: plastic, semi-dry or sliker (liquid clay). The plastic method is more advisable.

The following approximate technological scheme for plastic processing facing layer mix can be recommended:



Basic requirements on ceramic mix for brickbody and face layer are the following:

1. Strict variation range of clay mix consistencies for brickbody and face layer.

2. Adherence to clay mix sensitivity to drying for brickbody and face layer.

3. Observance of shrinkage allowances for brickbody and face layer.

4. Sufficiently high density of face layer body.

5. Observance of permissible content of soluble alkali metal sulphates, magnesium and calcium sulphates and other soluble salts.

The two-ply ceramics are commonly made as hollow bricks and ceramic stones. The de-airing extruders used to shape two-ply ceramic products are fitted with a longer barrel and a short spacer. The optimum auger speed depends upon clay properties and articles to be produced. For brickbody shaping correct vacuum should be not less than 95 per cent of total vacuum.

For face layer coating a special device is used which permits taking-in the face layer mix, compacting it to desired density and to provide uniform coat thickness (3-5(10) mm) on the edge and stretcher surfaces of the extruded column.

The principle of two-ply moulding is shown in Fig.

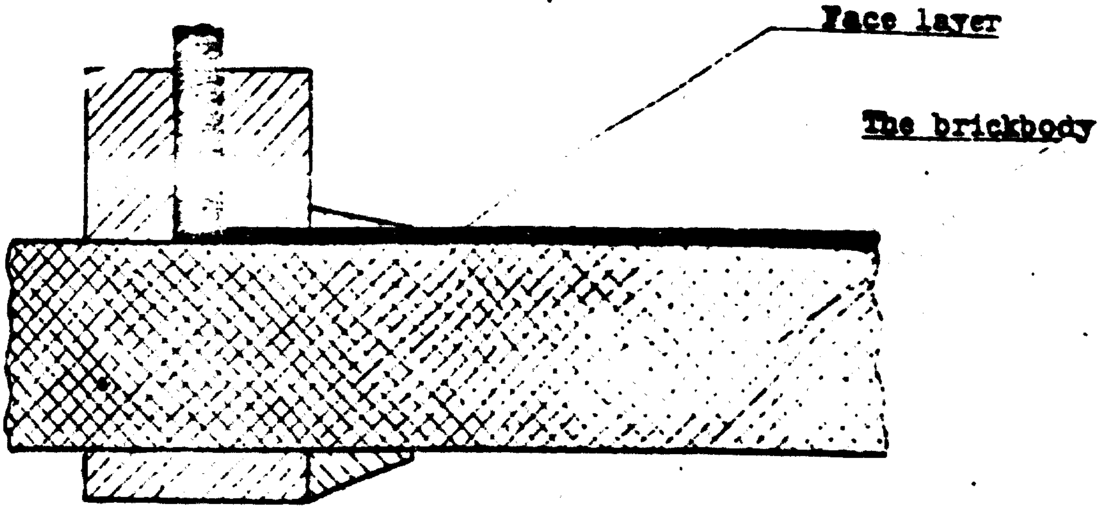


Fig.

This device consists of drive, feeder and additional extruder, and is synchronised with the main de-airing extruder. The capacity of machine is 5000-7000 bricks per hour.

The design of the machine is shown in Fig.

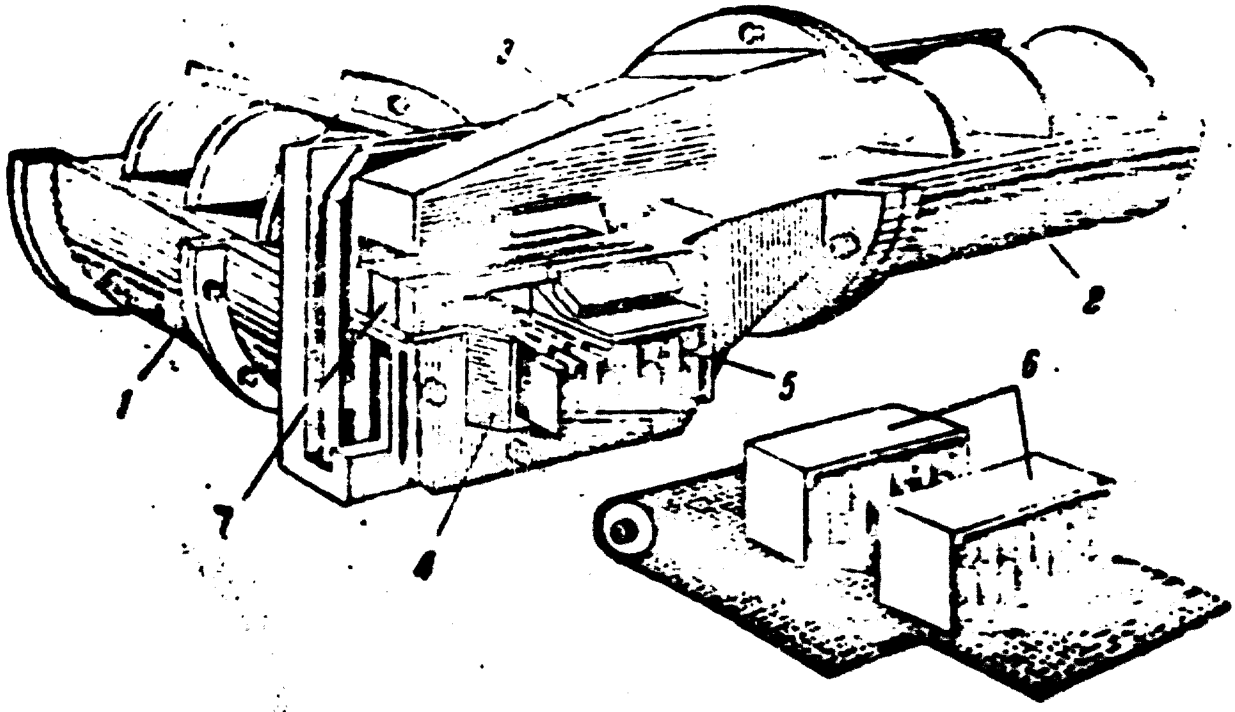


Fig.

1. Main extruder.
2. Device for face layer coating.
3. Spacer.
4. Die.
5. Extruded column.
6. Cut-off products.
7. Pressure board.

5. Ceramic Facing Tile

External facing of buildings with ceramic tiles is lasting, fine-looking and cheaper than any other facing material. It lacks the basic drawbacks of the plastering (no wet and labour consuming processes, lower repair expenses). The facing tile is successfully used in prefabricated large brick blocks and various wall panels.

The ceramic facing tile is produced mainly from light-firing refractory clays (with additives and without them) which have low firing temperature. The tiles can be glazed or unglazed, rectangular or square, with flat or grooved face surface. The back of the tile is either grooved, bunchy or slotted for strong adhesion to the wall to which it is grouted.

Manufacturing technique - mainly semi-dry pressing. The tile is dried in dryers of various designs (e.g. radiation dryers), and fired in multialit, roller and other kilns.

Assortment of semi-dry press ceramic facing tiles varies from rectangular tiles measuring 125x65x7 mm to 250x140x10 mm, square tiles measuring 68x68x7 mm.

IV. Conclusion and Recommendations

1. Raw Materials

In order to expand the clay resources and provide a required amount of studies and investigation of raw materials for the production of clay building materials in developing countries of Africa a unified technique of testing the raw materials should be worked out and adopted and the requirements to the raw material specified. It is our opinion that such unification of the test techniques should be aimed at establishing a series of tests and their extent for separate kinds of building materials and selecting principal methods of laboratory and technological tests. It is also desirable that a unified criterion of complete evaluation of the properties of raw materials by the results of technological tests be worked-out and recommended.

By unification of the methods of technological tests we do not mean a standardization of all the investigation methods comprising the volume of laboratory and shop batch clay testing. Such standardization would require selection of exsiting methods of various tests, development of new, more advanced methods and adoption of scientific and technological achievements along with these investigations. A unified technique of raw material testing could be of significant help to investigators in the studies of mineral resources for affective geological exploration and prospecting of new deposits of raw materials.

The following could be recommended as a minimum data required for determination and evaluation of the reserves of raw materials:

1. General information about the deposits.

2. Brief geological characteristic of the region.

3. The characteristic of geological and hydrological structure of the deposits.

4. Description of mining condition of exploiting the deposits.

5. Qualitative and technological characteristic of the useful mineral and other data.

It is expedient to work out a classification of clay reserves by the degree of their exploration, e.g. Category 4:

1. Complete and detailed exploration of clay deposits for production planning and exploitation.

2. Detailed exploration of the deposit for industrial development (designing technical project).

3. Preliminary exploration of the deposit for the workout of project problems.

4. Reconnaissance exploration of the deposit for the planning of geological and prospecting work.

To obtain preliminary estimate on the usefulness of the raw material for production of clay building materials by this or that method (plastic moulding or semi-dry pressing), it would be necessary to establish a series of investigations and their extent to determine physico-chemical and thermal properties of clays. Laboratory clay tests should provide sufficient data on the qualitative and technological characteristic of the raw material. The results of such tests should enable to make a decision about the usefulness of the raw material and recommend technological parameters for factory trials.

Shop tests of trial batches of ready product from the raw material should provide data for the work-out of technological parameters of production and serve as a basic for the conclusion on the usefulness of this raw material.

2. Production Technology

To enable a choice of production technologies for the manufacture of clay building materials for developing countries, a choice of technological equipment, technological parameters and operating conditions, it is advisable to organize technical information service, to expand information exchange and organize a show of practical production work.

It might prove expedient to organize on the African continent at existing research centres of an interregional or several regional posts for the studies of the raw material resourses for the production of clay building materials, for laboratory investigations and tests of raw materials and finished products. It could also be recommended to built at these posts pilot plants for production of ceramic products where shop batch tests could be carried out and technological production parameters could be worked out and improved.

At such posts work teams or committees could be organised for the development of recommendations for the selection of optimal clay building materials for various African areas.

It seems also advisable to work out technological production schemes for varying African conditions which could be subsequently used as a basis in projecting expansions of already existing and construction of new clay building materials plants in the developing countries of Africa.

Special attention should be paid to the training of skilled technologists and mechanics, workers and foremen. In view of this it seems expedient to work out a training programme, training and refresher courses for the workers of the building materials industry applicably to the conditions and requirements in the [illegible] ...ties in terms of organization and improvement [illegible] ...and raw materials as well as improvement of the product quality.

N.Z.Shinkarouk

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