Project Planning for Small and
Medium Scale Industries No.25

Ceramic Tableware Manufacturing Plant

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JAPAN CONSULTING INSTITUTE

This technical brochure was compiled to help in the drafting of a suitable plan for the construction of a Ceramic Tableware Manufacturing Plant.

The production scale and manufacturing process have been described in this brochure on the basis of a typical instance.

The profitability was estimated by fixing certain required conditions, which may differ from country to country.

We hope that the data contained in the brochure will help you to draw up the most suitable plan for the industrialization of your project.

In case a government or public organization requests the Japan Consulting Institute to conduct a feasibility study of the above industry for the purpose of establishing the most suitable plan, it is possible for us to carry this out free of charge.

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1. Introduction

Many of ceramic ware, which are made by firing clay hard, are being used around us. They include chinaware, glass, refractories, etc. Of which, chinaware is used for table (tableware), for building (tiles and bricks), for decoration (flower vase and ornament), for sanitation (toilet closet and washbasin), and for industry (insulator and technical parts).

Tableware is made of stone, wood, glass, chinaware and metal, of which the fired chinaware is mostly used. The reasons are that chinaware is clean, functional, easy to keep and handle, many designs can be selected, and cheap.

There are many kinds of chinaware.

Of the chinaware, porcelain is most excellent in quality. The body of porcelain is hard and transparent, does not absorb water, and make a clear sound when flipped. On the other hand, porcelain gets broken easily from spalling (caused by rapid heating and cooling in the manufacturing process). Porcelain can be classified into soft porcelain and hard porcelain according to its composition and properties.

The body of soft porcelain contains much flux such as feldspar, alkaline earth, and phosphate. Because of this, the body is easily vitrified at a comparatively low temperature (about 1,250°C). As its product, there are frit porcelain and bone china porcelain.

As hard porcelain does not contain much flux, it requires a high firing temperature (1,300 to 1,350°C) in manufacturing, and is usually fired with reduction flame. Porcelain is generally hard in the body, the glaze on the surface is very hard, and is excellent in acid resistance.

This hard porcelain dinnerware will be taken up in this brochure.

2. Kinds of Ceramic Dinnerware and General Characteristics of the Body

2.1 Kinds of Ceramic Dinnerware and Dinner Set

Explanation will be made here on each name of ceramic dinnerware.

Plate:
A shallow round dish, from which food is served. The name is used for many kinds of flat dishes.

Bowl:
A semiround vessel without a lid; the bottom of which being flat, it stands stably.

Cup:
A semiround or cylindrical tea cup with a handle. The cup is usually used together with a saucer.

Saucer:
A small shallow plate made for setting a cup on.

Casserole:
A deep dish with a lid, in which food is cooked.

Platter:
A large flat oval-shaped dish used for serving food.

Pot:
A container with a lid. The coffeepot and teapot have a handle. In case of sugarpots some have handle and others have no handle.

Creamer:
It resembles a cup in shape but has a spout. It is used for holding cream for coffee and tea.

Table 1 shows an example of ceramic dinnerware set composition, and Fig. 1 shows the shapes of each item.

Table 1 Dinnerware Set Composition

Dinner plate	8	8	8	–
Salad plate	8	8	–	6
B/B plate	8	8	8	–
Soup plate	8	8	8	–
Salad bowl	1	1	1	–
Tea/Coffee cup	8	8	8	6
Tea/Coffee saucer	8	8	8	6
Casserole	1 (2)	–	–	–
Oval platter	1	1	1	–
Sugar bowl	1 (2)	1 (2)	1 (2)	1 (2)
Creamer	1	1	1	1
Tea pot (with tea strainer)	1 (2)	1 (2)	–	1 (2)
	54 pc.	53 pc.	44 pc.	21 pc.

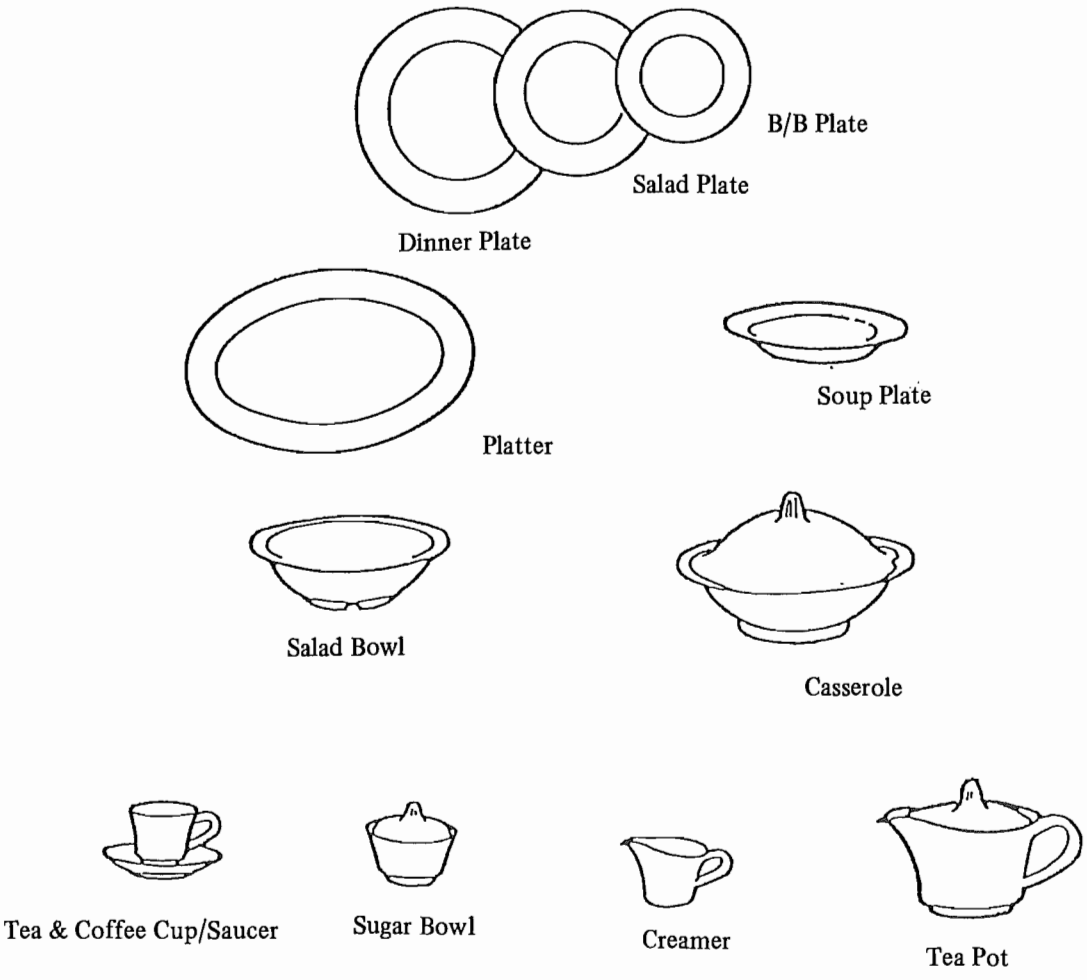

Fig. 1 Shapes of Dinnerware

A general definition on what is called the tableware or dinnerware is a set of chinaware to be used for serving a dinner having uniform decoration.

2.2 General Characteristic of the Body of Chinaware

The raw materials of chinaware being natural mineral such as clay, stone or their efflorescence, they exist widely and abundantly on the earth. If color and a firing temperature are not specified, almost all of clay can become fired ware. However, in case white product is required or the quality of product is specified, availability of proper raw materials will be limited. In obtaining a white body, iron content in the raw material will lower product quality. Hence, it needs to select the raw material that contains little iron. What generally called red clay contains much iron.

For making chinaware, plastic clay is required. There are many kinds of plastic clay. White clay has high refractoriness, and in case it is fired hard or is made half melted to manufacture porcelain, it needs flux material, for which feldspar is generally used. Besides clay and feldspar, silica is added to give porcelain transparency. Silica does not soften unless it is heated at a temperature higher than 1,700°C or so, but when silica is combined with clay and feldspar, various silicates are produced depending on a firing temperature, and will become flux material. Clay, feldspar and silica are main raw materials of chinaware, but these raw materials have different properties according to the place they are mined. Therefore, it needs to make a test to find the most appropriate mixing ratio. Clay is plastic raw material; chinastone, low plastic raw material; silica, non-plastic raw material; feldspar flux material. Detailed explanation will be made below on these raw materials.

3. Raw Materials

In making the ceramic dinnerware, the following raw materials are required.

(1) Plastic raw material
(2) Low plastic raw material
(3) Non-plastic raw material
(4) Flux material
(5) Auxiliary materials

3.1 Plastic Raw Material

Plastic raw material is generally an earthy mixture which occurs in nature, the principal component of which is fine aluminum silicate. When water is added to its fine powder it becomes plastic, and when it gets dried it comes to have strength, and when fired at a high temperature, it becomes hard. The minerals having such properties are plastic raw materials. The purpose of using these raw materials is to obtain formability and drying strength. Table 2 shows the chemical analysis of the representative plastic raw materials available in Japan.

3.2 Low Plastic Raw Material

Low plastic raw material is the chinastone, a stonelike raw material. This is a mineral consisting of feldspar, quartz, and sericite. In case the stone is finely crushed and water is added, it become viscous, which makes jiggering possible. Sericite brings about good sintering property, which serves for lowering the firing temperature.

Table 3 shows the chemical analysis of low plastic raw materials.

3.3 Non-Plastic Raw Material

The non-plastic raw material includes silica and silica sand. It is used for adjusting the viscosity and diminishing shrinkage because the plastic clay is too much viscous.

Table 4 shows the chemical analysis of non-plastic raw material.

Table 2 Chemical Analysis of Plastic Raw Materials

(Unit: %)

	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	Ig.loss	Total
Gairome clay A	52.4	31.9	1.12	0.77	0.25	0.20	1.41	0.18	11.62	99.85
Gairome clay B	47.58	35.42	1.58	0.59	0.25	0.31	0.51	0.16	13.14	99.9
Gairome clay C	54.22	30.46	1.29	0.7	0.12	0.33	1.42	0.17	11.00	99.71
Kaolin	47.70	35.43	0.7	0.13	3.16	0.33	0.79	1.15	10.56	99.81

Table 3 Chemical Analysis of Low Plastic Raw Materials

(Unit: %)

	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	Ig.loss	Total
China stone A	77.15	14.51	0.56	0.14	0.26	0.31	4.00	0.83	2.19	99.95
China stone B	77.67	15.47	0.13	0.27	0.22	0.05	3.78	0.15	2.26	100
China stone C	82.12	12.67	0.07	0.14	0.13	0.07	0.02	0.03	4.75	99.87

Table 4 Chemical Analysis of Non-plastic Raw Material

(Unit: %)

	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	Ig.loss	Total
Silica sand	98.0	1.1	0.03	–	–	–	–	–	0.3	99.43

Table 5 Chemical Analysis of Flux Material

(Unit: %)

	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	Na_2O	Ig.loss	Total
Feldspar A	78.45	12.8	0.54	–	0.32	0.28	0.51	5.83	1.45	99.9
Feldspar B	66.08	18.47	0.20	0.01	1.47	0.01	11.45	3.73	0.18	99.11
Feldspar C	74.4	14.33	0.13	0.03	0.55	0.02	8.09	2.35	0.13	100.93

3.4 Flux Material

As other raw materials such as clay and silica sand have high refractoriness, flux material, which melts easily, is used to make glass phase and to sinter them. However, if the glass phase is made too much, distortion and bubbles will occur while being fired. As flux material, there are three kinds, namely, potash feldspar, soda feldspar, and anothite.

Table 5 shows the chemical analysis of flux material.

3.5 Auxiliary Materials

As auxiliary materials, talc, calcium phosphate, sodium silicate, magnesium chloride are used; and as the flux for glaze, talc, dolomite, lime, ZnO etc. are used. Talc and calcium phosphate are used as the flux accelerant of the body when sintered and make, the body color fine. Sodium silicate is mixed when crushing is done in the ball mill and casting is performed so that the liquidity of slurry can be adjusted. Magnesium chloride is used as the coagulant and anti-sedimental agent of the raw material slurry.

3.6 Body Cake

Body cake is a compound clay which is made by compounding and processing various raw materials.

(1) An example of grain size of body cake

(Unit: %)

Grain size	a	b
Less than 20 μ	91	93
Less than 10 μ	75	73.5
Less than 5 μ	55.5	53.5
Less than 2 μ	40	37.5

(2) An example of compounding the body cake

(Unit: %)

Raw material	a	b
Feldspar	21	24
Silica sand	12	14
China stone	29	26
Kaolin	11	12
Elutriated clay	27	24

4. Manufacturing Process

In the manufacture of chinaware, particularly dinnerware, there are many that are complicated in the size and shape. Manufacturing process is comprised of forming (jiggering and casting), finishing, glazing, biscuit firing, glost firing, and decoration. Body cakes of different composition are sometimes used for jiggering and for casting. But it makes the control of process and equipment complicated. It is therefore desirable to use body cake of the same composition.

In the casting, oval plates and teapots are generally made. It is necessary to make a careful study on the selection of raw materials and deflocculent and on water quality, while taking into consideration the liquidity of slurry, casting speed, nature of de-moulding, time required for de-moulding, stability after de-moulding, and difficulty of processing.

As to the plaster to be used for the working mould, hardness and bearing strength are more required for the roller machine rather than water absorption; while for casting, the plaster having good water absorption is more required than the one having large bearing strength.

There are many of chinaware, whose shapes are complicated, but so long as the body is relatively thin, and does not require quick drying, there seldom occurs a problem in the process of drying and biscuit firing.

Glazing of plates and casted ware (teapot, sugarpot, creamer, and casserole) is made differently. In te case of plates, the automatic glazing machine is employed, while in the case of casted ware, the method of hand dipping is used.

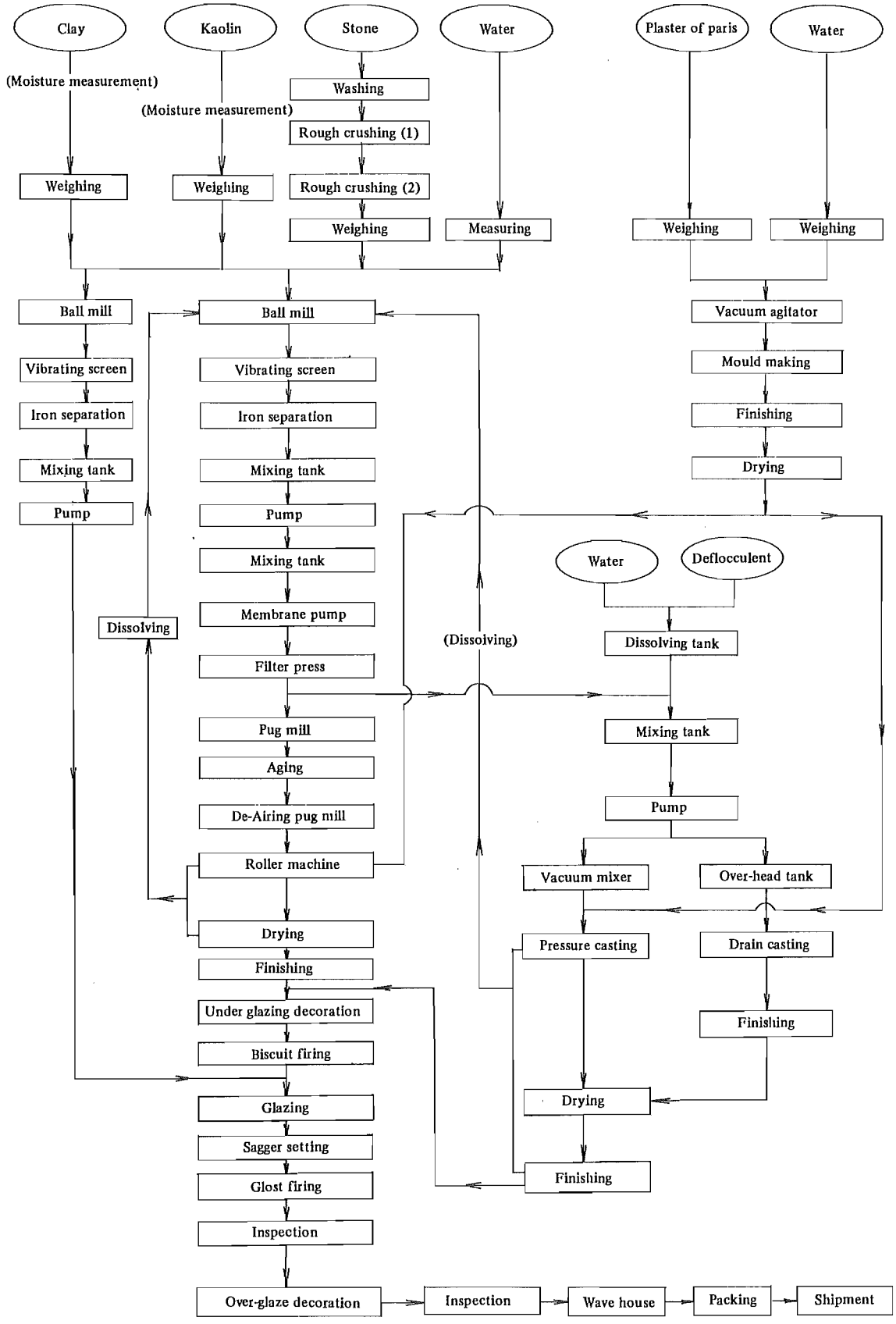

Fig. 2 Flow Chart

In case gas is used as fuel for glost firing, the loading on cart shelves in the furnace is mainly adopted for cups and casted ware, and saggering is done for plates. In case fuel is oil, saggering is generally adopted.

In the glost firing of porcelain, the reduction firing at a temperature of over 1,200°C is done in order to convert ferric oxide Fe_2O_3 contained in the body into ferrosoferric oxide Fe_3O_4, and burning is done in the state of air shortage.

Recently a tunnel kiln is used for the biscuit firing and glost firing. Owing to the improvement of the facilities and the enhancement of efficiency, uniform firing can be achieved unless the shape of chinaware is very peculiar.

Since the decoration kiln has also been ameliorated in function, a short-time firing has become possible.

The general manufacturing process of porcelain will be shown in Fig. 2 Flow Chart, and explanation will be made on the outline of each process.

(a) Crushing

As the raw material stones are delivered almost in the form of a block, the extraneous matter attached on their surface is first washed away. Then they are roughly crushed to approximately 25 mm in diameter by jaw crusher, and are carried by conveyor into a roll crusher. The raw materials that passed through the roll crusher are roughly crushed to less than 15 mm in diameter to be stored in each raw material pit.

(b) Compounding

(1) Body preparation

The standard compounding for hard porcelain is reportedly made at the ratio of 50% kaolin, 25% feldspar and 25% silica. Kaolin alone is very low in plasticity and in the strength of green ware. Hence, part of the kaolin is displaced with plastic clay. Its quantity is from 15 to 20%. The less quantity of plastic clay generally brings about a body for a high grade final product of high whiteness.

In the case of general porcelain the firing temperature of which is less than SK12, the composition of raw materials will be: plastic clay 35~45%, silica 20~30%, and feldspar 30~40%.

Even if the quantity of iron and titanium contained in the raw materials is very small, it will deteriorate the whiteness and transparency of the body. Care must be taken on this point, especially when a high grade product is to be manufactured.

(2) Glaze preparation

As the porcelain glaze, there are talc glaze, limestone glaze, and dolomite glaze. For the under glaze decoration, limestone glaze is better, while for the over glaze decoration, talc glaze is better.

For example, the composition of white glaze of SK12 firing ratio is: feldspar 37%, kaolin 10%, silica 37%, talc 10%, zinc white 3%, zirconium silicate 2%, barium carbonate 1%. As to kaolin, it is advisable that a half of it is used in the form of raw kaolin and another half in the form of calcined one in order to adjust the viscosity of raw glaze. Also, since talc is apt to precipitate it must be used after calcined in the glost kiln.

(c) Fine grinding

The body and glaze materials are finely ground in a ball mill together with ball stones. The ratio of raw material, ball stone and water is: 100% of raw material, 120% ball stone, and 100~120% water. Depending on raw material to be used, the quantity of water should be reduced as much as possible. A little quantity of defloculant is sometimes added, but it is desirable not to use defloculant because it affects the property such as plasticity of body cake. The grinding hours is 24~30 hrs. for body material and 60~100 hrs. for glaze material. The body and glaze materials, which were finely ground, are put into a storage tank respectively after passing through a vibrating screen and a magnetic ferro filter.

(d) Dehydration

The slurry of body is transferred to a mixing tank, and is sent into a filter press by a membrane pump for dehydration. The suitable water content of the cake after dehydration, that is filtered cake, is 19~20%. In case the water of the filtered cake is excessive, it must be stocked for several days to get dried.

(e) Forming

① Roller machine moulding

The filtered cake, that was stocked in a proper state, is formed by a roller machine after primary mixing, aging, and the secondary mixing. The heated rotary roller head of the roller machine comes down on the plaster mould on the shaft to make the body cake form a specified shape. In the forming the number of rotations of the thing to be formed and of the roller head is important. Also, the thickness and weight of green ware are important. Sampling inspection must be done at least twice a day. There are many other things to be controlled, namely, the dispersion of water content in the body cake, the abrasion of roller head, etc.

② Casting

Unlike the roller machine forming which uses solid raw materials, casting is done by pouring the slurry raw material in the mould. The mould is made of calcined plaster and is called plaster mould. These are two methods of casting, pressure casting and solid casting. The pressure casting is used for making plaster. In the former method, plaster moulds are piled up over and over again, and the slurry is pressed by air compressor to be supplied forcibly into the mould. This method is suitable for mass production. In the latter method, slurry is supplied to each plaster mould by natural flow from a storage tank without using an air compressor.

(f) Drying

The green ware, which was formed by a roller machine or in the casting, is put into a drying chamber together with the plaster mould. In the drying chamber is a shelf, on which the plaster mould (and the green ware) are placed. The shelf is driven by power. The drying hours differ according to the shape of a product. It is done until the de-moulding of green ware can be accomplished. There are two kinds of dryer, one is the atmospheric drying method and the other is the quick drying method. In drying the green ware, the drying conditions must be controlled by taking into consideration the temperature, humidity and draft.

(g) Biscuit firing

The green ware, which was de-moulded after being dried, undergoes the first firing in the tunnel kiln. This is called "biscuit firing". The green ware on a car is fired in the furnace at a temperature of about 800°C for 15 to 20 hours. The purpose of biscuit firing is to give strength to the product before glazing and to give the glaze stickiness.

(h) Glazing

Glaze is made by crushing and fine crushing of raw materials, as in the case of body cake. Glaze differs from body cake only in the raw materials to be used. In glazing plates, an automatic glazing machine is used, whereby the supply of product and glazing are done automatically. In glazing the casted product, it is impossible to use an automatic glazing machine because the shape is complicated, and its glazing is done by manual hand-dipping. In the glazing dust cleaning must be done completely and the glaze thickness must be uniform.

(i) Glost firing

The glazed product is carried into a glost firing kiln to be fired by reduction flame at a temperature of more than 1,300°C. This is called "glost firing". The glazed product, which was put on a car, passes through the kiln by power to be fired for about 30 hours. In order to protect the product at the time of firing and to raise the carrying capacity of car sagger is used. The tunnel kiln, in which porcelain were is fired with reduction flame, is separated into three zones, namely, preheating zone, firing zone, and cooling zone.

① Preheating zone

In this zone, the water contained in the body is evaporated, and the organic matter in the body which was not completely burned in the biscuit firing, and also the organic matter in the glaze are burned up. The temperature is lower than 1,050°C.

② Firing zone

In this zone, the highest temperature of the product fired in the kiln becomes about 1,350°C. The firing atmosphere is the reduction state. The reason is that the iron contained in the body is liable to be oxidized into Fe_2O_3 and the color of the product become light yellow; and the reduction firing is done to prevent that by converting the said iron into FeO (ferrous oxide).

③ Cooling zone

In this zone, the product, which was fired at a temperature of about 1,350°C, is cooled so that the product does not crack when it is exposed to air at the outlet of the kiln. The product is cooled rapidly at first, and then cooled gradually. The rapid cooling exerts a great influence on the glaze brightness and whiteness of the product. Fig. 3 shows an outline of the tunnel kiln.

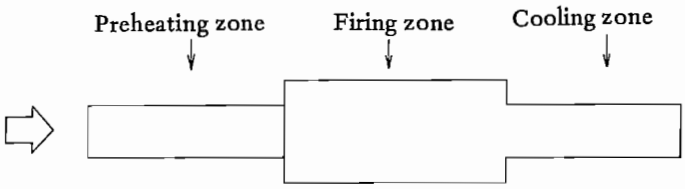

Fig. 3 Outline of Tunnel Kiln

(j) Decoration

The method of decoration is roughly classified into the over glaze decoration and the under glaze decoration.

① Under glaze decoration

This decoration is made on the biscuit fired body. In this method, there are hand painting method, transfer paper method, and stamping method. Of these methods, stamp decoration is used very often. Glaze is applied on the decorated body and then glost firing is done.

② Over glaze decoration

The white body fired in the glost firing kiln is decorated using the transfer paper and liquid gold. Recently, screen printed transfer paper of a water slide type is mainly adopted. The firing temperature is 700~850°C.

(k) Decoration kiln

This kiln is exclusively used for the over glaze decoration, and generally is of a muffle type. This is aimed at glazing the inorganic pigment at a low temperature. What is characteristic of this kiln is that its firing temperature being low, it can fire and print many kind of colors and delicate designs.

(1) Sagger

For th porcelain to be fired at a high temperature, a carborundum sagger or a mullite sagger is often used. The carborundum sagger is superior in the heat transfer and in the resistance against rapid heating and cooling, but its price is high. What is adopted comparatively often is the mullite sagger. In selecting either of them, consideration must be given to the firing hours of the glost firing tunnel kiln and to the heat curve. In the present mechanized manufacturing process, the quality of sagger is so important a factor that affects the quality of the product.

(m) Plaster of paris

There are two kinds of plaster of paris which are used at present; one is alpha plaster and the other is beta plaster. They have their respective characteristic.

① Alpha plaster

As alpha plaster is produced by calcination under high pressure and high temperature, it has high compressive strength and high anti-abrasion. In the forming using a roller machine, it is desirable to employ alpha plaster because body cake has little water and the moulding pressure is high.

② Beta plaster

The plaster to be used for casting is not required to have large compressive strength, but is required to have good water absorption so that the work is done efficiently. In this case, beta plaster which has so far been used is preferred.

5. Outline of a Model Plant

In this brochure the porcelain dinner set manufacturing plant has been adopted as a model because the dinner set is very popularly used.

5.1 Kinds of Product and Production Scale

(1) Kinds of product

The 54 pc. dinner set shown below are the kind to be manufactured.

Name of product	Size	Unit quantity of set
Dinner plate	10½"	8
Salad plate	7½"	8
B/B plate	6½"	8
Soup plate	8"	8
Salad bowl	6"	1
Coffee cup		8
Saucer		8
Casserole (with lid)		1 (2)
Platter		1
Sugar pot (with lid)		1 (2)
Creamer		1
Tea pot		1 (2)
Total		54 pc. set

(2) Production scale

The plant will produce 60,000 sets a year.

Name of product	Production		Unit weight	Total weight	
	pcs./month	pcs./year	gr.	ton/month	ton/year
Dinner plate	40,000	480,000	650	26.0	312
Salad plate	40,000	480,000	350	14.0	168
B/B plate	40,000	480,000	300	12.0	144
Soup plate	40,000	480,000	390	15.6	187.2
Salad bowl	5,000	60,000	350	1.75	21
Coffee cup	40,000	480,000	130	5.2	62.4
Saucer	40,000	480,000	140	5.6	67.2
Casserole	5,000	60,000	800	4.0	48
Platter	5,000	60,000	1,200	6.0	72
Sugar pot	5,000	60,000	320	1.6	19.2
Creamer	5,000	60,000	210	1.05	12.6
Tea pot	5,000	60,000	600	3.0	36
Total	270,000	3,240,000		95.8	1,149.6

5.2 Required Quantity of Raw Materials and Auxiliary Materials

(a) Required quantity of raw materials

Item	ton/month	ton/year
Plastic raw material	40	480
Low plastic raw material	30	360
Non-plastic raw material	20	240
Flux material	30	360
Auxiliary materials	10	120
Total	130	1,560

(b) Required quantity of auxiliary materials

Sagger:
10 tons/month 120 tons/year
Plaster:
5 tons/month 60 tons/year
Packing material:
5,000 sets/month 60,000 sets/year

5.3 Plant Operation

(a) The whole process except firing

Annual number of operating days:
300 days/year
Operating hours: 8 hrs./day,
2,400 hrs./year

(b) Firing process

Annual number of operating days:
360 days/year
Operating hours: 24 hrs./day,
8,640 hrs./year

5.4 Required Quantity of Utilities

Electric power (excluding lighting and maintenance)	2,040,000 kWh/year
Fuel (L.P. gas)	1,500 tons/year
Industrial water	10,000 tons/year

5.5 Plant Area

200 m x 175 m	35,000 m^2

5.6 Building Area

Compound clay making section		
80 m x 42 m		3,360 m^2
Forming, firing section		
40 m x 132 m		5,280 m^2
Mould making section, laboratory		
30 m x 20 m		600 m^2
Product storage		
40 m x 36 m		1,440 m^2
Stock yard (semi-product, sagger, etc.)		
		4,560 m^2
Office	30 m x 20 m	600 m^2
Total		15,840 m^2

5.7 Required Number of Personnel and Placement

	Worker	Engineer	Total
Compound clay making section	10	1	11
Forming section	40	1	41
Glazing section	20	1	21
Kiln section			
Biscuit firing kiln, loading and unloading	5		
Glost firing kiln, loading and unloading	10	1	32
Decoration kiln, loading and unloading	4		
Firing section	12 (3 shifts)		
White body inspection section	5	1	46
Decoration section	40		
Mould making section	5	1	6
Packing/inspection section	15	1	16
Maintenance section	3	1	4
Laboratory	3	1	4
Others	6	–	6
Sub-total	178	9	187
Clerical section			20
Factory manager			1
Total			208

5.8 List of the Required Machinery and Equipment

The following shows the necessary machinery and equipment in the plant.

Raw Material Crushing Section

Stone washing machine	1 set
Hammer crusher for kaolin and clay rocks	1 set
Jaw crusher	2 sets
Roll crusher	1 set
Dust collector	1 set
Weighing scale	2 sets
Belt conveyors	1 lot
Material storage and silo	1 unit
Cargo lift	1 set

Body Preparation Section

Ball mill	2 sets
Storage tank with mixing agitator	2 sets
Slip pump	1 set
Vibrating screen	1 set
Magnetic ferro filter	2 sets
Storage tank with mixing agitator	2 sets
Membrane pump	2 sets
Filter press	2 sets
Oil-hydraulic pump unit	1 set
Double shaft pug mill	1 set
De-airing auger machine	2 sets
High speed blunger	1 set
Slip pump	1 set
Jet cleaner	1 set
Water flow meter	1 set
Slip, air and water pipe	1 lot

Glaze Preparation Section

Ball mill	2 sets
Storage tank with mixing agitator	2 sets
Slip pump	1 set
Vibrating screen	1 set
Magnetic ferro filter	2 sets
Slip tank with mixing agitator	1 set
Membrane pump	1 set
Pot mill unit	2 sets
Water flow meter	1 set

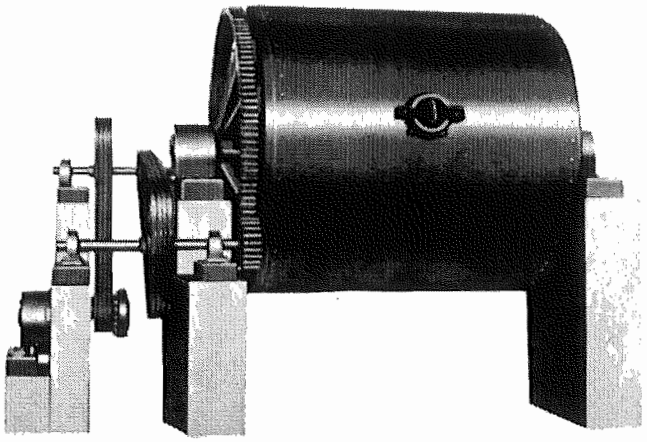

Photo 1 Ball Mill

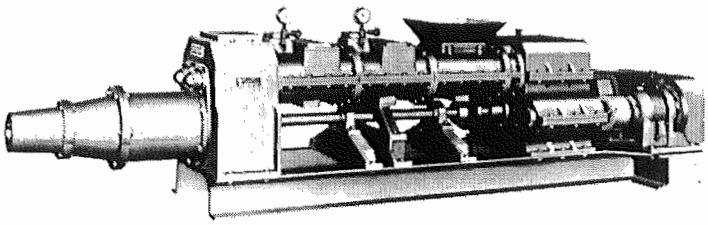

Photo 2 De-Airing Auger Machine

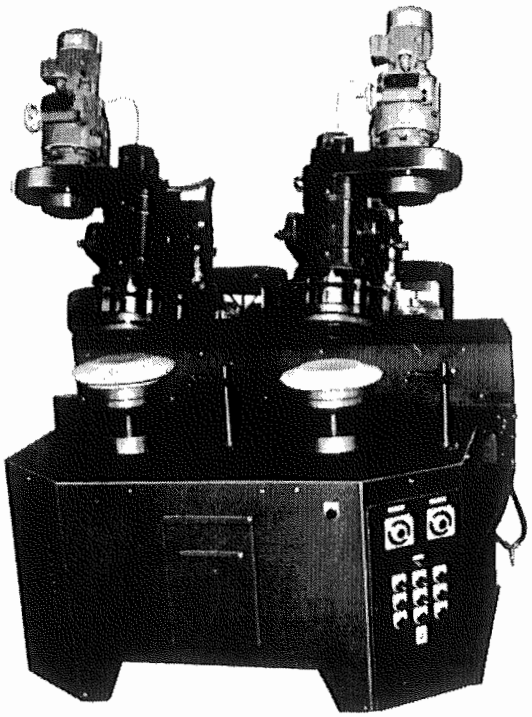

Photo 3 Roller Machine

Glaze, water and air pipe	1 lot

Jiggering Section

Clay cutting machine	5 sets
Roller machine for cup	1 set
Dryer for leather hard of cup	1 set
Cup edging machine	1 set
Table conveyor for handle joining	1 set
Slip rotor for handle joining	1 set
Dryer for white drying of cup	1 set
Roller machine for small and middle plate	2 sets
Dryer for small and middle plate	1 set
Roller machine for middle and large plate	1 set
Dryer for middle and large plate	1 set
Edge finishing machine	3 sets
Table conveyor for kiln car loading of green ware	1 set
Hot air generator	1 set

Casting Section

High-speed blunger	2 sets
Under-ground type slip agitator	2 sets
Slip pump	2 sets
Over-head slip tank with agitator	1 set
Under-ground type high-speed blunger	1 set
Slip pump	1 set
Drain casting table with tank	2 sets
Table conveyor for finishing works	1 set
Working table	7 sets
Dryer for drying of drain casted ware	1 set
Slip vacuum agitator	1 set
Vertical type solid casting machine	1 set
Potter's wheel	4 sets
Dryer for drying of solid casted ware	1 set
Hot air generator	1 set
Solid casting stand for cup handle	1 set
Moisture control room for cup	1 set
Slip piping materials	1 lot

Under Glaze Decoration & Glazing Section

Table conveyor	4 sets
Dust removing machine	4 sets
Dust collector	1 set

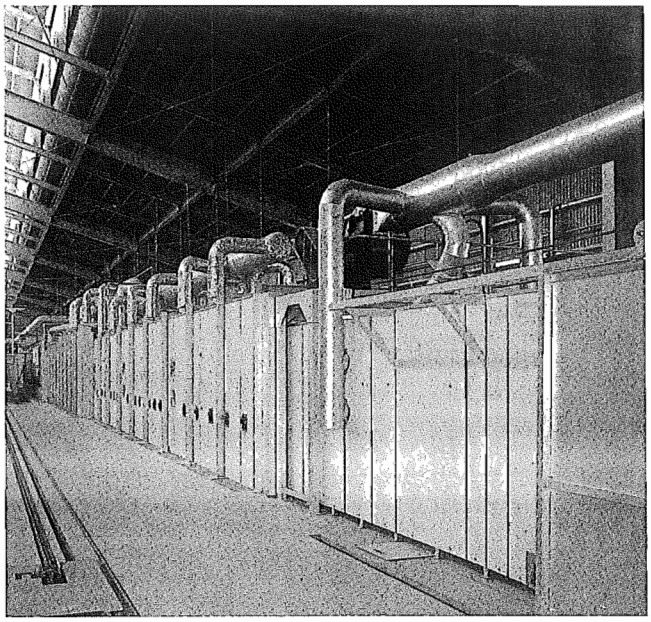

Photo 4 Tunnel Kiln

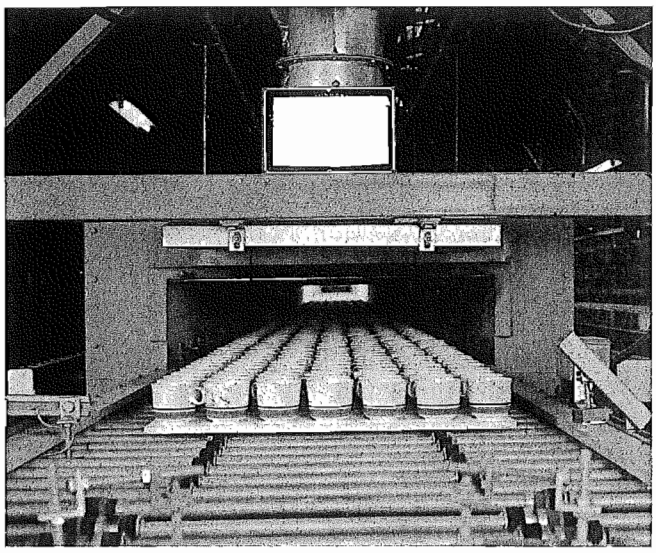

Photo 5 Cup Firing

Back stamping machine	2 sets
Working table	10 sets
Automatic colour lining machine	2 sets
Silicon pad stamping machine	3 sets
Turn table	4 sets
Automatic glazing machine	2 sets
Automatic glaze cleaning conveyor	4 sets
Glaze dipping tub	2 sets
Over-head type glaze storage tank	1 set
Glaze, water and air pipe	1 lot

Firing Section

o Biscuit firing tunnel kiln	(1 unit)
type of kiln: open-flame tunnel kiln	
total kiln length: 55 m	
Gas combustion & air dynamic apparatus	1 set
Rails, vehicles & car pusher	1 set
Steel structural materials	1 set
Thermo & power control instruments	1 set
Refractories	1 set
o Glost firing tunnel kiln	(1 unit)
type of kiln: open-flame tunnel kiln	
total kiln length: 65 m	
Gas combustion air dynamic apparatus	1 set
Rails, vehicles & car pusher	1 set
Steel structural materials	1 set
Thermo & power control instruments	1 set
Refractories	1 set
o Decoration firing roller hearth kiln	(1 unit)
type of kiln: muffle roller hearth kiln	
total kiln length: 25 m	
Gas combustion air dynamic apparatus	1 set
Kiln body housing & rollers	1 set
Trays, plates stands & baskets	1 set
Thermo & power control instruments	1 set
Refractories	1 set

Over Glaze Decoration Section

Turn table	2 sets
Dust removing machine	2 sets
Dust collector	1 set
Belt conveyor for over-glaze	2 sets
Table conveyor for stock & tray	1 set
Potter's wheel for decoration work	20 sets

Glost Ware Inspection Section

Working table	6 sets
Table conveyor for inspection work	1 set
Polishing machine	5 sets
Dust collector	1 set

Final Inspection & Packing Section

Table conveyor for stock	1 set
Working table	5 sets
Roller conveyor unit	1 set
Manual type hand boxer	10 sets

Mould Making Section

Storage bin	2 sets
Weighing scale	1 set
Water tank	1 set
Vacuum agitator for plaster of paris	1 set
Working table	3 sets
Turning wheel	12 sets
Original mould jigger for round shape	1 set
Finishing jigger for mould foot	1 set
Free center drilling machine	1 set
Chamber room for drying of mould	1 set
Hot air generator	1 set
Mould making tools	1 lot
Case moulds (mother moulds) for working mould	1 lot

Laboratory Equipment

Standard sieve set	1 set
Pot mill unit	2 sets
Refractoriness tester	1 set
Infrared moisture meter	1 set
Viscometer	1 set
Sagger cones	1 set
Electronic optical pyrometer	1 set
Slide caliper	1 set
Dilatometer	1 set
Manual potter's wheel	3 sets
Mechanical mortar	1 set
pH meter	1 set
Picno meter	1 set
Electronic precision balance	1 set
Revolution meter	2 pcs.
Clay hardness tester	2 pcs.
Measuring cylinders & beakers	1 set
Labo stirrer	1 set
Small filter press	1 set
Autoclave tester	1 set
Test furnace	1 set

Electric furnace	1 set	Miscellaneous Equipment	
Drying oven	1 set		
De-airing auger machine	1 set	Air compressor	3 sets
Jaw crusher	1 set	Air tank for above compressor	1 set
Working table	1 set	Small tools for production	1 set

5.9 Plant Layout

Fig. 4 shows an outline of plant layout.

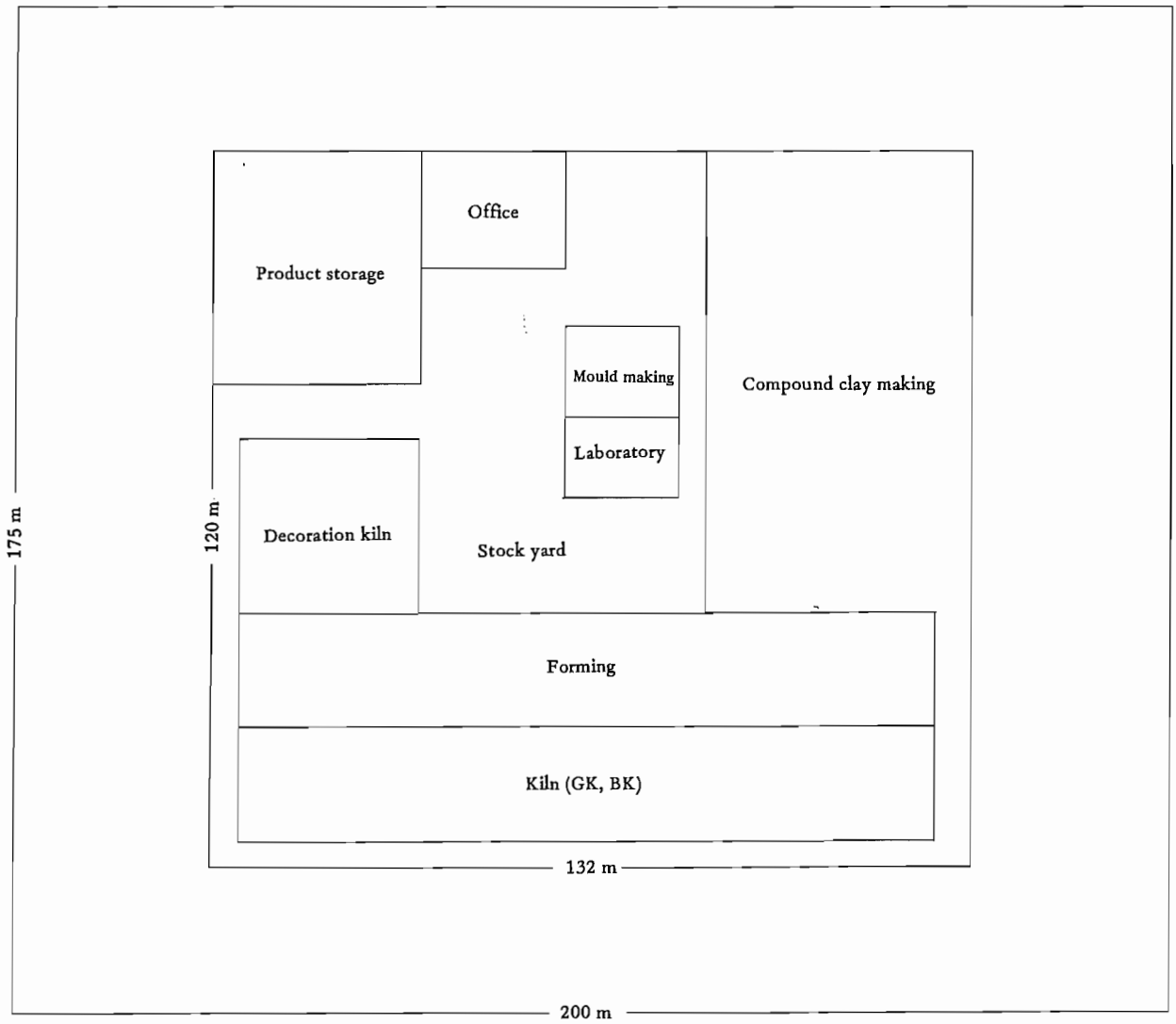

Fig. 4 Plant Layout

6. Machinery and Equipment Cost and Building Construction Cost

The following shows the machinery and equipment cost and the building construction cost.

(1) Cost of machinery and equipment

	F.O.B. in U.S. Dollar
Raw material crushing section	191,000
Body preparation section	452,000
Glaze preparation section	108,000
Jiggering section	562,000
Casting section	274,000
Under-glaze decoration and glazing section	473,000
Firing section	
Biscuit firing tunnel kiln	434,000
Glost firing tunnel kiln	933,000
Decoration firing roller hearth kiln	338,000
Over-glaze decoration section	95,000
Glost ware inspection section	27,000
Final inspection and packing section	23,000
Mould making section	108,000
Laboratory equipment	132,000
Miscellaneous equipment	63,000
Spare parts	162,000
Sagger and plaster of paris	258,000
Total	US$4,633,000

(2) Building construction cost

Item	Building area m^2	Unit price US$	Amount US$
Compound clay making section	3,360	220	739,200
Moulding, firing section	5,280	220	1,161,600
Mould making section, laboratory	600	220	132,000
Product storage	1,440	220	316,800
Stock yard (semi-product, sagger, etc.)	4,560	220	1,003,200
Office	600	220	132,000
Total	15,840		US$3,484,800

7. Profitability

In calculating the production cost, it is necessary to fix the basis of calculation for each country. But it being difficult to make such calculation according to the conditions in each country, the production cost will be calculated in this brochure on the basis of the following assumption.

7.1 Preconditions

(1) Fixed capital

(a) Unit construction cost of factory and office buildings

US$220/$m^2$

(b) Price of machinery and equipment

FOB Japanese port price as of 1988

(c) Spare parts cost

10% of the FOB price of machinery and equipment

(d) Freight and insurance cost

10% of the FOB price of machinery and equipment

(e) Erection cost

5% of the FOB price of machinery and equipment

(f) Civil engineering cost for foundation

10% of the FOB price of machinery and equipment

(g) Supervision cost

10% of the FOB price of machinery and equipment

(h) Commissioning cost

5% of the FOB price of machinery and equipment

(i) Training cost

5% of the FOB price of machinery and equipment

(j) Contingency

10% of the FOB price of machinery and equipment

(2) Working capital

(a) Raw material cost for two months

(b) Product inventory for one month

(3) Production cost

(a) Raw material cost

Plastic raw materials (clay, kaolin)	US$300/ton
Low plastic raw material (china stone)	US$170/ton
Non-plastic raw material (silica)	US$150/ton
Flux material (feldspar)	US$300/ton
Auxiliary materials (talc, calcium phosphate, others)	US$400/ton

(b) Auxiliary materials cost

Sagger, shelf plate	US$700/ton
Plaster	US$650/ton
Packing material	US$2.5/set

(c) Utilities cost

Electric power	US$0.07/kWh
Industrial water	US$0.20/ton
Fuel (L.P. gas)	US$250/ton

(d) Labor cost

The annual labor cost is as below.

Factory manager	US$14,000
Engineer	US$8,000
Clerical staff	US$5,000
Worker	US$4,000

(e) Maintenance cost

3% of the FOB price of machinery and equipment

(f) Depreciation cost

Straight-line method will be adopted for depreciation.

Depreciation of machinery and equipment (US$11,129,250 – 3,484,800) x 7%	US$535,112
Depreciation of building US$3,484,800 x 3%	US$104,544

(g) Insurance cost

0.5% of the fixed capital US$55,646

(h) Selling and administration cost

5% of the annual sales US$240,000

(i) Interest

One-second of the fixed capital is to be covered by a long-term loan, and its annual rate of interest is 10% US$556,463

(j) Exchange rate

The exchange rate of the US dollar to the Japanese Yen is assumed to be:

US$1.00 = ¥130

7.2 Capital Required

(1) Fixed capital

Land	Not included
Building construction cost	US$3,484,800
Machinery and equipment cost	US$4,633,000
Spare parts cost	US$463,300
Freight and insurance cost	US$463,300
Erection cost	US$231,650
Civil engineering for the foundation	US$463,300
Supervision cost	US$463,300
Commissioning cost	US$231,650
Training cost	US$231,650
Contingency	US$463,300
Sub-total	US$11,129,250

(2) Working capital

Raw materials for two months	US$111,700
Product inventory for one month	US$236,592
Sub-total	US$348,292

(3) Capital required (1) + (2) US$11,477,542

7.3 Production Cost

(a) Raw material cost

Plastic raw materials	US$144,000
Low plastic raw material	US$61,200
Non-plastic raw material	US$36,000
Flux material	US$108,000
Auxiliary materials	US$48,000
Sub-total	US$397,200

(b) Auxiliary material cost

Sagger, shelf plate	US$84,000
Plaster	US$39,000
Packing material	US$150,000
Sub-total	US$273,000

(c) Utilities cost

Electric power US$0.07/kWh x 2,040,000 kWh	US$142,800
Industrial water US$0.2/ton x 10,000 tons	US$2,000
Fuel US$250/ton x 1,500 tons	US$375,000
Sub-total	US$519,800

(d) Labor cost

Factory manager US$14,000 x 1	US$14,000
Engineer US$8,000 x 9	US$72,000
Clerical staff US$5,000 x 20	US$100,000
Worker US$4,000 x 178	US$712,000
Sub-total	US$898,000

(e) Maintenance cost	US$138,990
(f) Depreciation cost	US$639,656
(g) Insurance cost	US$55,646
(h) Selling and administration cost	US$240,000
(i) Interest	US$556,463
Production cost	US$3,718,755

7.4 Annual Sales

The unit selling price of porcelain ware was fixed referring to the international price of the middle-grade products; and on the basis of which, the annual sales was calculated.

Product	Unit price	Annual number of sets sold	Annual sales
Dinnerware (54 pc. set)	US$80	60,000 sets	US$4,800,000

7.5 Profitability

On the basis of the above conditions, profitability was estimated as follows.

Annual sales	US$4,800,000
Annual production cost	US$3,718,755
Profit	US$1,081,245

The annual profit will be US$1,081,245, which corresponds to 22.5% of the annual sales.

The profit ratio of total capital is 9.4%. Therefore, the profitability may be considered good.

8. Conclusion

Tableware is very important to us because it is used every day, and is indispensable for our daily life.

As the living standard is improved, people have come to show interest in the tableware in every country. Accordingly, tableware which is functional and having excellent designs is required. As long as this requirement exists, the demand for tableware will not diminish.

The ceramic tableware, representative of the tableware, has a very long history and has steadily expanded its market. It may be said that the tableware will expand its market continuously in the future as well.

The ceramic tableware manufacturing industry is labor intensive. In case cheap labor force is available, the competitiveness in product export will develop; and with the advance of ceramic machines, good products can be manufactured from the startup. Because of this, it may be said that the ceramic tableware manufacturing is one of the valuable businesses.

It may be a profitable industry especially in the region where labor, fuel, and raw material can be acquired sufficiently.

Project Planning for Small and Medium Scale Industries

No. 1 Rice Milling Plant and Rice Bran Oil Manufacturing Plant
No. 2 Plastic Woven Bag Manufacturing Plant
No. 3 Container Board Manufacturing Plant
No. 4 Plastic Blow Bottle Manufacturing Plant
No. 5 Concrete Block Manufacturing Plant
No. 6 Glassware Manufacturing Plant
No. 7 Galvanized Iron Sheet Manufacturing Plant
No. 8 Fishing Net Manufacturing Plant
No. 9 Ice Making, Refrigeration and Cold Storage Plant
No.10 Starch and Syrup Manufacturing Plant
No.11 Instant Noodle Manufacturing Plant
No.12 Surimi and Surimi-Based Food Manufacturing Plant
No.13 Polyethylene Shopping Bag Manufacturing Plant
No.14 Retreading Tire Manufacturing Plant
No.15 Husk Fired Thermal Power Plant
No.16 Fishmeal Manufacturing Plant
No.17 Assorted Animal Feed Manufacturing Plant
No.18 Sanitary Napkin Manufacturing Plant
No.19 Sanitary Ware Manufacturing Plant
No.20 Toilet Tissue Manufacturing Plant
No.21 Powder Milk Manufacturing Plant
No.22 Mosquito Coils Manufacturing Plant
No.23 Solar Pond Power Generation Plant
No.24 Manufacturing Plant of Textile Products for Medical Use
No.25 Ceramic Tableware Manufacturing Plant

Project Planning for Small and Medium Scale Industries No. 25

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