Project Planning for Small and
Medium Scale Industries No. 22

Mosquito Coils 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 Mosquito Coils 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.

CONTENTS

1. Introduction

It was toward the end of the eighteenth century that the idea of making mosquito repellent incense was conceived. Before that, plants were burned to prevent the mosquito's attack with the smoke thus generated, without killing them.

It was the end of the nineteenth century when pyrethrum was first used as active ingredient of mosquito repellent incense, probably desiring to repel and kill insects.

In those days the mosquito repellent incense had the shape of a stick, and around 1910 it came to have the present form of coil.

In the early stage mosquito coils were formed by hand. Around 1914 punched mosquito coils were made by machine. It was around 1950 when the synthesis of raw material pyrethroid and mechanization of manufacturing method were introduced.

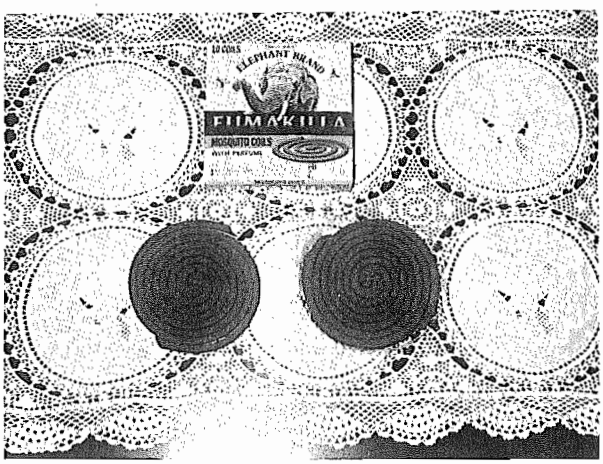


Photo 1. Mosquito Coils

The demand for mosquito coils seemed to have been declined due to the appearance of a spray insecticide and an electric mosquito killer, but in reality mosquito coils are in large demand occupying such a big market share that insecticide has seldom enjoyed. The reason may be attributable to the fact that mosquito coils are easy to handle and have another merits. Especially, it is a commodity that was invented for the convenience of users.

2. Raw Materials

Mosquito coils are composed of the following raw materials.

For making mosquito coils various raw materials as are shown above are blended at a fixed ratio, kneaded by adding water, extruded and stamped out.

The blending ratio of the components is as follows: Insecticide is less than 1%, wood powder 20 to 30%, pyrethrum powder 20 to 30%, bonding agent 20 to 30%, and others several percents.

2.1 Insecticide

The main component of insecticide is pyrethroid. The power of pyrethroid used in mosquito coils is given in Table 1.

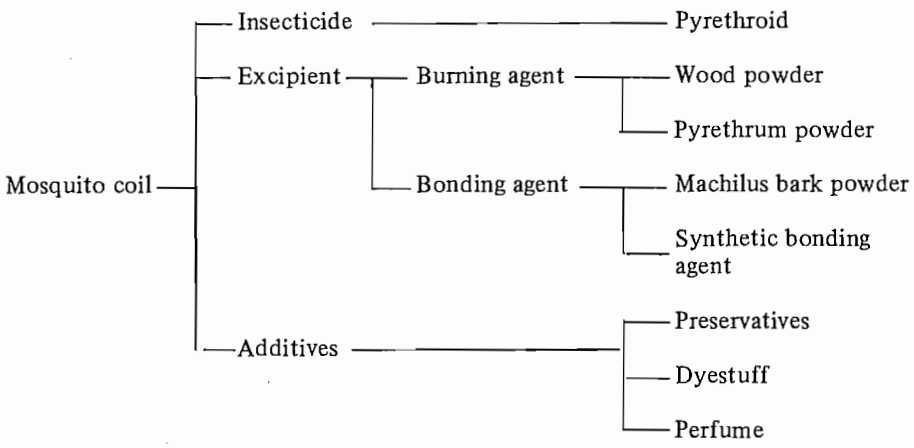


Table 1. Insecticide Effect of Pyrethroids against Common Gnat Curel Pipiens Pallens

Density	Furamethrin		Proparthrin		Allethrin	
	KT-50	Killing rate	KT-50	Killing rate	KT-50	Killing rate
(%)	(Min.) (Sec.)	(%)	(Min.) (Sec.)	(%)	(Min.) (Sec.)	(%)
1.0	52	100.0	2.25	54.5	2.25	57.5
0.8	1.48	100.0	2.43	45.0	2.43	49.1
0.6	1.50	98.3	2.48	28.5	3.44	37.5
0.4	2.22	65.8	3.55	28.5	4.18	23.3
0.2	3.50	47.9	4.49	19.5	6.04	2.5

Note: According to the $0.5m^3$ box-type method test.

2.2 Excipient

Mosquito coils are a special agent that is gradually burned and fumed, displaying the power of insecticide. The excipient has an important role of restraining the thermal decomposition of the effective component and also prolonging the burning time as much as possible.

The excipient is roughly classified into burning agent and bonding agent. The former involves wood powder and pyrethrum powder, and the latter involves starch, synthetic bonding agent and machilus bark powder.

(1) Burning agent

(a) Wood powder
Wood powder is sawdust of cedar, cypress and other miscellaneous trees. Crude powder is used after pulverized. Wood powder has a role of keeping heating power.

(b) Pyrethrum powder
This consists of the residue that remains after extracting pyrethrin from the dried pyrethrum flower, the powdered stems and leaves of pyrethrum. Pyrethrum powder gives mosquito coils a unique odor, and is also expected to enhance the power of insecticide with a very small amount of residual pyrethrin.

(2) Bonding agent

Bonding agent is also called "starch powder", which is used for bonding the burning agent. The bonding agent is made of ordinary starch and synthetic CMC (carboxymethyl cellulose). But machilus bark powder is mainly used for mosquito coils.

Machilus bark powder is powdered leaves of a plant called machilus thunbergii, sieb et zucc. This is a tall tree growing naturally in warm coastal area. Its leaves and trunks contain much mucilage. The mucilage consists of D-xylose and L-arabinose. Its major producing country is Thailand.

2.3 Additives

In making mosquito coils, preservative, which prevents the generation of mold, dystuff and perfume are generally used as additives, in addition to insecticide and agents.

(a) Preservative
As mosquito coils prepared by stamping contain much moisture, they easily get moldy during hot and humid season or in such a region.
Accordingly, it is necessary to dry mosquito coils in the production process. For this, natural drying was mostly used in former days, adopting partially artificial drying.

However, when a rainy or cloudy weather continues while mosquito coils are being dried naturally, they get moldy, deteriorating the product quality. To keep mosquito coils from getting moldy, it is necessary to add preservative.
Recently, it has become possible to use only artificial drying (Air circulation drying system) through the whole drying process, whereby mosquito coils hardly get moldy while being dried.
As preservative, benzoic acid, salicylic acid, dehydroacetic acid, potassium sorbate, para-hydroxy benzonic acid ethyl are used.
Preservative is not a main component of mosquito coils, but is important to keep high commodity value.

(b) Dyestuff

For mosquito coils, such dyestuff as malachite green has long been used in general.

(c) Perfume

Perfume is generally added to mosquito coils, alleviating their irritating odor generated when burned.

3. Production Process

Production process of mosquito coils is shown in Fig. 1.

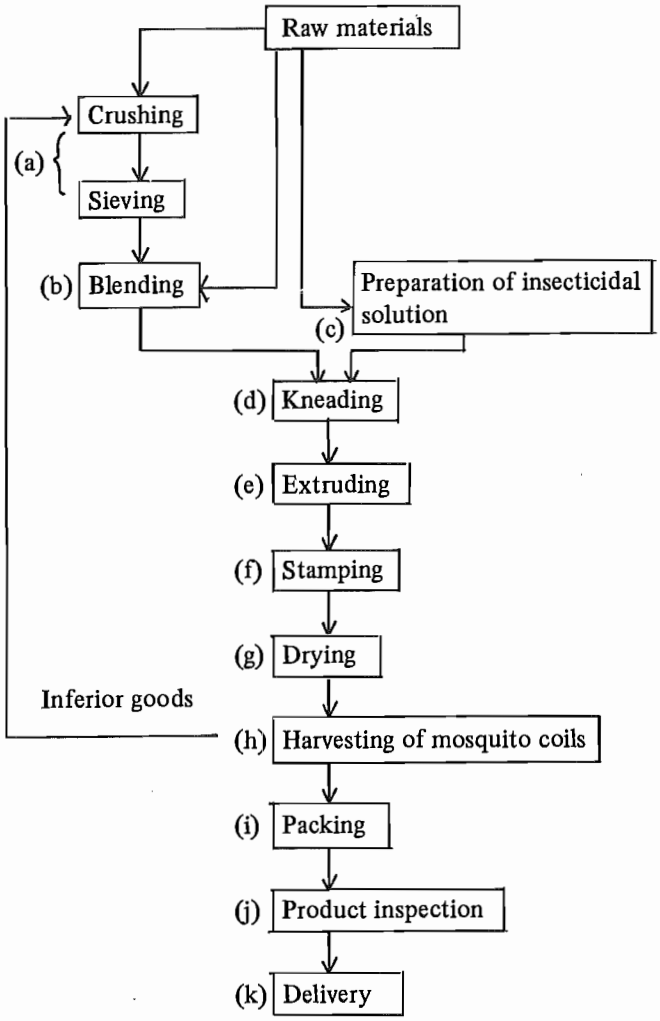


Fig. 1. Production Process of Mosquito Coils

(a) Crushing

The received pyrethrum residue, machilas bark powder and wood powder are sieved, and the raw material that does not meet the prescribed grain size (less than 80 meshes is desirable), is crushed by crushing machine and is sieved.

(b) Blending

The various powdered raw materials and synthetic bonding agent powder are weighed for the fixed quantity, and are mixed in a blending machine until they get completely blended.

(c) Preparation of insecticide solution

A fixed quantity of insecticide component is blended with emulsifier, and is diluted with water. Also a fixed quantity of dyestuff and preservative are dissolved in water.

(d) Kneading

The blended powder is weighed properly and is fed into a kneading machine. The fixed quantity of dyestuff, preservative solution and insecticidal solution is added.
Further, when the water runs short, it is added up to the fixed quantity, and kneading is made until it gets proper viscousity.

(e) Extruding

The blended raw material is fed into the hopper of the extruding machine, and the raw material having the shape of a board is pushed out continuously.

(f) Stamping

The extruded raw material is cut into a fixed length, sent by a belt conveyor to a stamping machine and stamped out.
In the case of using a rotary-type stamping machine, the stamping is done while the rotating table finishes its turn. Mosquito coils are discharged on a wire net which was set beforehand by an operator.
The wire nets, on which the punched mosquito coil bodies are placed, are piled up on a cart.

(g) Drying

The mosquito coil piled up on the cart are carried to the drying process.
In drying the mosquito coils, air circulation drying system has recently taken the place of natural drying.
The system utilizes the following dehumidifying principle: "The saturated vapor pressure is dependent on temperature, and the moisture in the air is condensed into dew by lowering the temperature and is removed from the air."
Circulated air is applied to wet mosquito coils by a pressure fan, creating a humid air with almost saturated vapor pressure at a fixed temperature. The wet air is led to a low-temperature room to remove the contained moisture. The dehumidified air is heated and used again to dry up mosquito coils.
Mosquito coils are dried by repeating this process. Under this method, mosquito coils can be dried so long as there is difference between the temperature of the air applied to mosquito coils and that of the low temperature room. Hence, it is unnecessary to

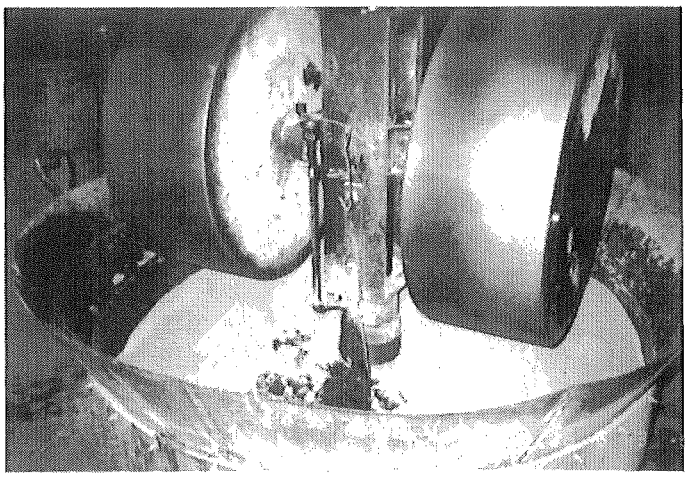


Photo 2. Blending

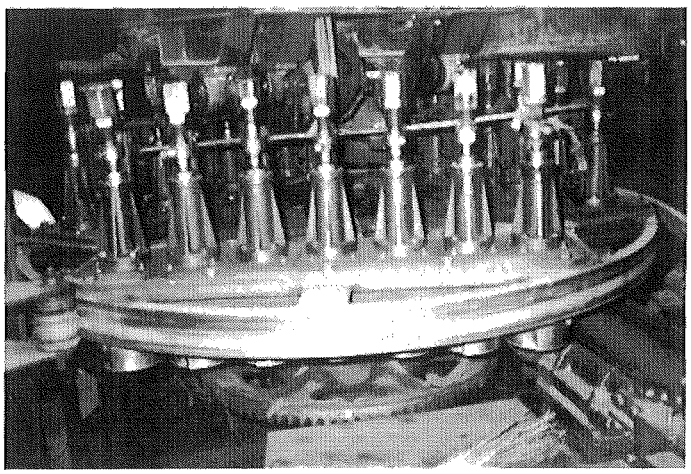


Photo 3. Stamping

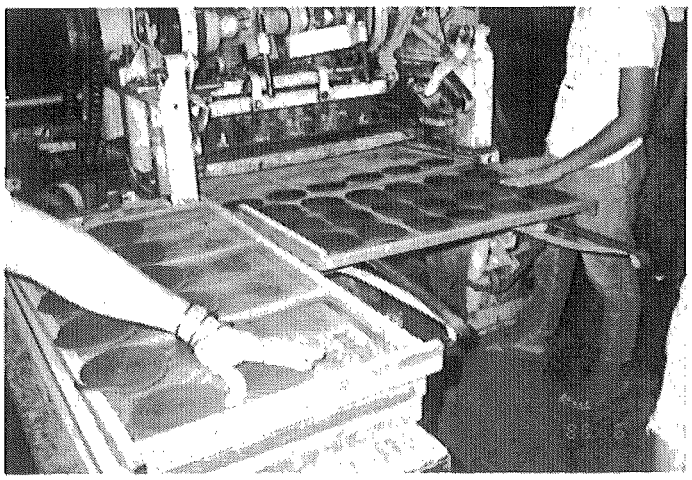


Photo 4. Harvesting

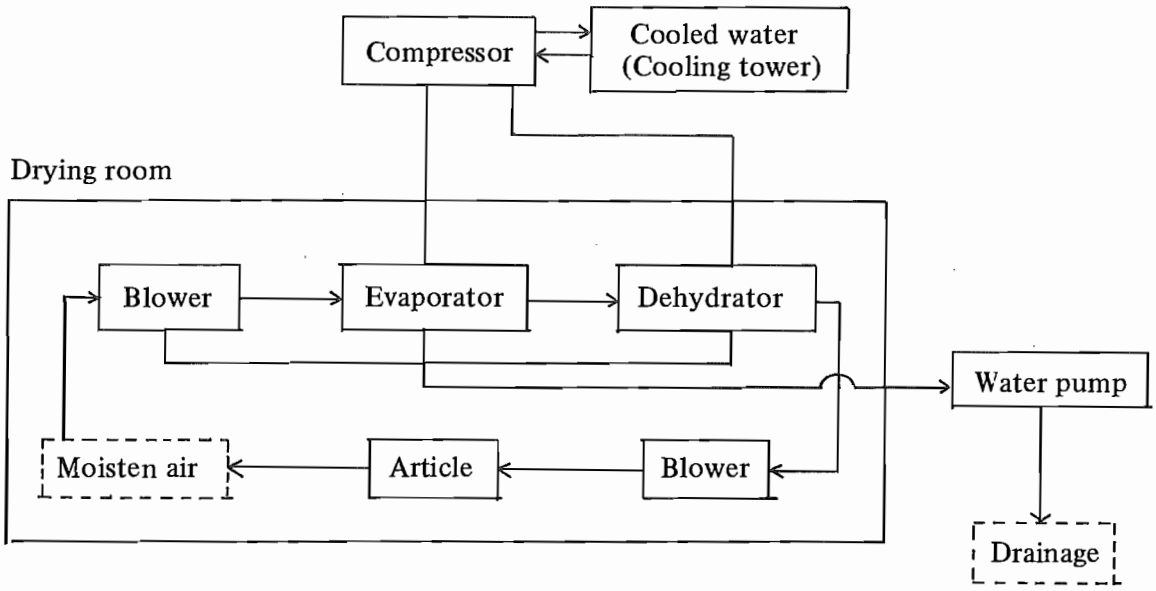


Fig. 2 Outline of the Air Circulation Drying System

use high temperature, and the drying temperature can be set at a comparatively low level. Therefore, in drying mosquito coils, it is possible to set a proper temperature, preventing an adverse effect, such as bending by high temperature.

(h) Harvesting

After drying, the cart is taken out of the drying room, and the dried mosquito coils are removed by hand from the wire net and are sent to packing process.
Harvesting is done, while existence of any broken coil, flaw, deformation, mixing of foreign matters are inspected with eyes. Inferior goods are fed back to the crushing process for reuse.

(i) Packing

A predetermined number of mosquito coils harvested are put into a small box, and the small boxes are packed into a corrugated cardboard box.

(j) Inspection of product

An appropriate quantity is taken out of each lot of products to be inspected, and only the products passed the inspection are delivered.

4. Mosquito Coils Manufacturing Model Plant

In drawing out a plan of a mosquito coil manufacturing plant, it is necessary to investigate the availability of insecticide and wood powder as well as pyrethrum powder.

For the proposed model plant, air circulation drying system has been adopted instead of natural drying.

4.1 Production Scale

Daily production: 55,000 pcs/8 hrs.
Monthly production: 1,375,000 pcs/month (working for 25 days a month)
Annual production: 16,500,000 pcs/year (working 300 days a year)

When one case is assumed to contain 300 pcs, the number of cases a month will become 4,580, and 55,000 a year.

Note: One piece of mosquito coil consists of two single coils.

4.2 Required Quantity of Raw Materials

Consumption of raw materials:

	36.38 ton/month
Insecticide (Technical):	100 kg/month
Preservative:	70 kg/month
Coloring matter:	70 kg/month
Perfume:	15 kg/month
Pyrethrum residue:	9 ton/month
Wood powder:	18 ton/month
Machilus bark powder:	9 ton/month
Synthetic bonding agent:	120 kg/month

4.3 Utilities

Electricity: 110 kWh/hr
110 kWh/hr x 8 hr x 300 day
= 264,000 kWh/year

Steam: 800 kg/day
Fuel oil: 60ℓ/day x 300 day
= 19,200ℓ/year

Industrial water: 2 ton/day
2 ton/day x 300 day
= 600 ton/year

Note: Electricity does not include lighting use.

4.4 Machinery and Equipment Required

The following shows the main machinery and equipment required.

Crushing machine and sieving machine:	2*
Crushing capacity: more than 400 kg/8 hr.	
Dust collector:	1
Blending machine: Capacity 1,000ℓ	1
Kneading machine:	1
Crusher:	1
Extruding machine:	1
Cutting machine:	1
Stamping machine:	1
Air circulation drying system:	1
Conveyor for packing:	1
Boiler:	1
Cart:	150
Wire net:	9,000 pcs.
Inspection equipment:	1

* Two sets may not be enough, depending on the grain size of the purchased raw material.

4.5 Cost of Machinery and Equipment

The cost of machinery and equipment cited in 4.4 is as below.

Total cost of machinery and equipment:
About US$ 574,000 (FOB price)

Note 1. The exchange rate of the US dollar to the Japanese Yen is assumed to be US$ 1 = ¥150.

2. The costs of lighting facilities, electric wire, steam pipe, water supply and drainage pipe, exhaust gas duct, fire fighting appliances are not included in the total cost of machinery and equipment.

4.6 Plant area and Buildings

(1) Plant area	2,952m²
(2) Buildings	1,460m²

4.7 Plant Layout

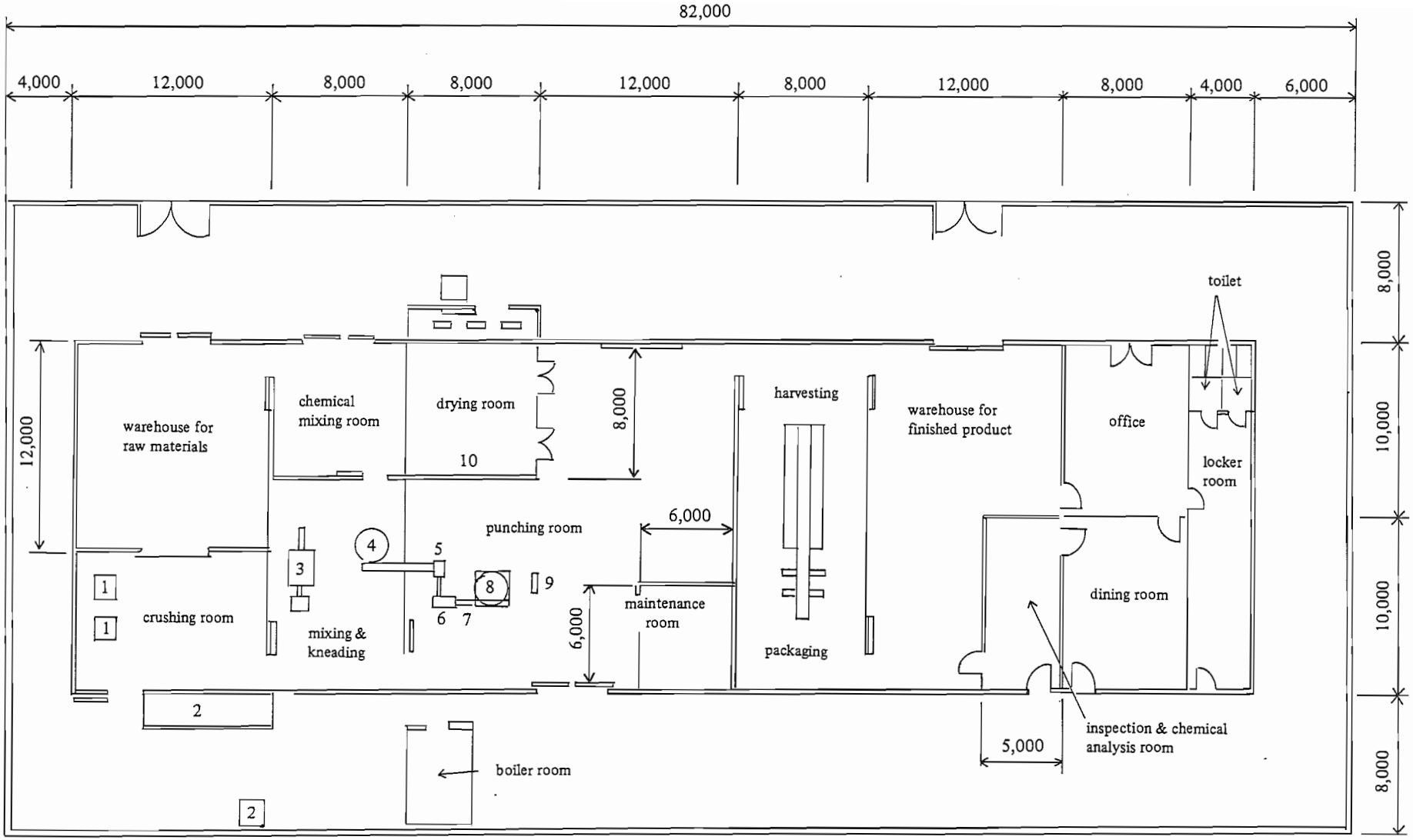
Layout of the mosquito manufacturing plant is as shown in Fig. 3.

4.8 Number of Personnel Required

A total of 36 persons are required as follows.

	Male	Female
Factory manager	1	-
Managerial officer	2	-
Clerical worker	1	2
Engineer *	3	1
Skilled worker	1	-
Unskilled worker	6	19
Total	14	22

Note: * Engineer is composed of two male mechanicians, and one male analyzer and one female analyzer.



1. crushing machine & sieving machine
2. dust collector
3. mixing machine
4. kneading machine
5. crusher
6. extruding machine
7. cutting machine
8. stamping machine
9. lift
10. drying room
11. conveyor for packaging

Note: The figures shown in the layout indicate the processing order.

Fig. 3 Layout of Mosquito Coils Plant

5. Production Cost and Profitability

In calculating the production cost, it needs to take into account the real condition of each country concerned, but it being difficult to do so, the calculation in this brochure will be made on the following basic conditions.

5.1 Basic Conditions

(1) Fixed capital

(a) Construction cost of buildings:
US$ 200/m²

(b) Machinery and equipment cost:
FOB Japanese port as of 1987.

(c) Spare parts cost is assumed to be 10% of the FOB price of machinery and equipment.

(d) Freight and insurance cost is assumed to be 10% of the FOB price of machinery and equipment.

(e) Civil engineering cost for foundation is assumed to be 10% of the FOB price of machinery and equipment.

(f) Erection cost is assumed to be 6% of the FOB price of machinery and equipment.

(g) Supervision cost is assumed to be 10% of the FOB price of machinery and equipment.

(h) Commissioning cost is assumed to be 5% of the FOB price of machinery and equipment.

(i) Training cost is assumed to be 3% of the FOB price of machinery and equipment.

(j) Contingency is assumed to be 10% of the FOB price of machinery and equipment.

(2) Working capital

(a) Raw material cost for one month.

(b) Inventory of product for one month.

(3) Production cost

(a) Raw material cost

Raw materials	US$ 0.036/pc
Packing material	US$ 0.011/pc

(b) Utilities cost

Electricity	US$ 0.06/kWh
Industrial water	US$ 0.20/ton
Fuel oil	US$ 0.20/ℓ

(c) Labor cost

Annual labor cost is as follows:

Factory manager	US$ 12,000
Managerial officer	US$ 6,000
Clerical worker	US$ 3,000
Engineer	US$ 5,000
Skilled worker	US$ 4,000
Unskilled worker	US$ 3,000

(d) Maintenance cost

Maintenance cost is assumed to be 3% of the FOB price of machinery and equipment.

(e) Depreciation cost

Straight-line method will be adopted for depreciation.

Depreciation of machinery and equipment will be:

(Fixed capital – building construction cost) x 7%

Depreciation of buildings is assumed to be 3% of the building construction cost.

(f) Insurance cost

Insurance cost is assumed to be 0.5% of the fixed capital.

(g) Selling and administration cost

Selling and administration cost is assumed to be 3% of the annual sales.

(h) Interest

One-second of the fixed capital will be covered by a long-term loan, and its annual rate of interest is 10%.

Note: The exchange rate of the US dollar to the Japanese Yen is assumed to be US$ 1 = Y150.

5.2 Capital Required

(1) Fixed capital

		US$
Plant area	2,962m²	—
Building construction	1,460m²	292,000
Machinery and equipment		574,000
Spare parts		57,400
Ocean freight and insurance		57,400
Civil engineering for foundation		57,400
Erection		34,440
Supervision		57,400
Commissioning		28,700
Training		17,220
Contingency		57,400
Subtotal	US$	1,233,360

(2) Working capital

Raw material cost for one month:	US$	64,625
Inventory of product for one month:	US$	84,310
Subtotal	US$	148,935

(3) Capital required (a) + (b) US$ 1,381,755

5.3 Production Cost (per year)

(a) Raw material cost

Raw materials	US$	594,000
Packing material	US$	181,500
Subtotal	US$	775,500

(b) Utilities

Electricity: US$ 0.06/kWh x 264,000 kWh/year	US$	15,840
Industrial water: US$ 0.20/ton x 600 ton/year	US$	120
Fuel oil: US$ 0.20/ℓ x 19,200 ℓ/year	US$	3,840
Subtotal	US$	19,800

(c) Labor cost

	US$
Factory manager: US$ 12,000 x 1 person	12,000
Managerial officer: US$ 6,000 x 2 persons	12,000
Clerical worker: US$ 3,000 x 3 persons	9,000
Engineer: US$ 5,000 x 4 persons	20,000
Skilled worker: US$ 4,000 x 1 person	4,000
Unskilled worker: US$ 3,000 x 25 persons	75,000
Subtotal	US$ 132,000

(d) Maintenance cost

US$ 574,000 x 3% US$ 17,220

(e) Depreciation cost

Machinery and equipment: US$ 941,360 x 7%	US$	65,895
Buildings: US$ 292,000 x 3%	US$	8,760
Subtotal	US$	74,655

(f) Insurance cost

US$ 1,233,360 x 0.5% US$ 6,167

(g) Selling and administration cost

US$ 1,386,000 x 5% US$ 69,300

(h) Interest

US$ 1,233,360 x 1/2 x 10% US$ 61,668

Annual production cost US$ 1,156,310

The production cost of mosquito coils per 10 single coils (5 pcs) will become as follows:

US$ 1,156,310 ÷ 3,300,000 = US$ 0.35

5.4 Annual Sales

The price of mosquito coils will be fixed as below on the basis of international price:

10 single coils (5 pcs)/small box: US$ 0.42

Annual sales will be:

US$ 0.42 x 16,500,000 pcs/year ÷ 5
= US$ 1,386,000

5.5 Profitability

On the basis of the above conditions, the profitability of the model plant will be estimated as below.

Annual sales amount of product	US$ 1,386,000
Annual production cost	US$ 1,156,310
Profit (before tax)	US$ 229,690

Profit ratio to sales revenue:

US$ 229,690 ÷ US$ 1,386,000 = 16.6%

Profit ratio to capital required:

US$ 229,690 ÷ US$ 1,381,755 = 16.6%

6. Other Necessary Matters

(1) In planning the construction of the proposed plant, it is necessary to investigate the following matters in advance.

(a) Permission regarding the manufacture of insecticide.

(b) Legal restriction on the factory noise.

(c) Loal electricity specifications such as voltage, cycle, etc.

(d) Insecticide components and percentage of contents in similar mosquito coils being sold in the same district.

(2) As the crushing machine and stamping machine generate noises and vibration while being operated, it is not appropriate to construct the plant in the vicinity of residential quarter.

(3) In receiving the raw materials and in processing them, it is necessary to take adequate consideration against the coming in into the crushing machine of such foreign matters as metal, ore, etc. Because the existence of such foreign matters often causes sparks to emit which may ignite raw materials.

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

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