Project Planning for Small and
Medium Scale Industries No.26

Manufacturing Plant of Ethanol for Medical Use

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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 Manufacturing Plant of Ethanol for Medical Use.

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

Fossil fuel such as coal, oil, oil shale, and natural gas run out when used, while alcohol can be produced every year as raw material or fuel as long as sunlight, water and air are available, and is attracting attention as such. As raw materials of alcohol there are such biomass as molasses, sugar cane juice, beet, root crop, rice, corn, etc.

Gasohol, which uses alcohol as fuel, is being used or its use is under plan in various countries. For instance, Brazil is putting out alcohol on a large scale using sugar cane juice as raw material, and adds it to gasoline or uses alcohol as it is to save oil (gasoline) and millions of cars that use alcohol are running.

In some parts of the U.S.A. alcohol is similarly used by making it from corn and adding several percents to gasoline. In Japan it is difficult to put gasohol to practical use because the price of raw material is high, researches, however, are now under way to make alcohol fermentation of cellulose material which abounds in Japan.

2. Use and Standards of Alcohol

2.1 Use

Alcohol is a basic raw material and is widely used. It can roughly be classified into four purposes, namely, potable, industrial, medical and gasohol. The most basic, important role alcohol plays in medical circles is the use for sterilization. In case a plant makes alcohol only for the medical purpose, the production scale is comparatively small, but if the scale is expanded, it can put out much more alcohol which is usable for other purposes. The countries, that are importing alcohol at present, can economize on foreign currency if they produce alcohol and decrease the import volume. In case alcohol is used for gasohol, as was mentioned earlier, it will lead to improving the energy situation in the future. Alcohol manufacturing plant is one of the fundamental plants for which it is necessary to acquire technology.

Of the purposes of alcohol, what require a relatively small production scale and are payable are two, potable and medical. In this brochure alcohol for medical use will be taken up.

2.2 Standards

Table 1 shows the Japanese standards on the alcohol for medical use (the Japanese Pharmacopoeia Standards). The standards on the industrial and liquors are also shown in Table 2 for reference.

3. Principle of Alcohol Production

In the production of alcohol by fermentation, it uses the principle that yeast decomposes glucose into carbon dioxide gas and ethyl alcohol in the anti-aerobic state using the energy evolved for its life.

$$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$$

In case there is enough oxygen and glucose, yeast propagates using them as food, but does not produce alcohol. As the ordinary yeast does not digest starch, it must first be changed into glucose, as is shown in the following formula.

$$(C_6H_{10}O_5)_n + nH_2O \rightarrow nC_6H_{12}O_6$$

Yeast converts the glucose into alcohol.

4. Raw Materials

There are at present two main materials of alcohol; glucose material and starch material. The typical glucose materials are molasses, sugar cane

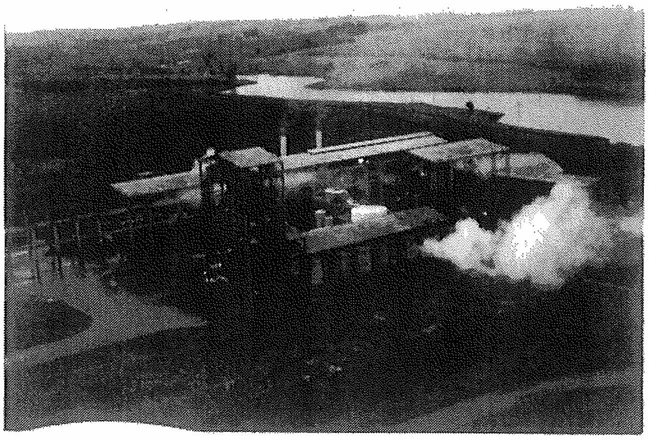

Photo 1. Factory of Alcohol Manufacturing

juice, beet and pineapple. As the starch material are root crops such as sweet potato, potato, tapioca, rice as well as corn. As these raw materials are being used as foodstuffs, it needs to pay attention not to encroach on the sphere of food. Therefore, it is necessary to boost up the yield of said crops, and then those of inferior quality are to be used as raw material of alcohol, and at the time of a bad crop, the production of alcohol should be decreased so that the raw materials of alcohol thus saved is used as food in order to prevent a shortage of food. As glucose material, molasses, the by-product of sugar is utilized in fairly many countries.

A large portion of the production cost of alcohol is occupied by raw materials, which makes it very important to select the raw materials.

Table 1. The Japanese Pharmacopoeia Standards (The Tenth Revision – 1981)

Test items \ Classification		Ethanol	Dehydrated ethanol	Ethanol for sterilization
Concentration (Ethyl alcohol v/v%) (by specific gravity)		95.1 ~ 95.6 (15°C)	More than 99.5 (15°C)	76.9 ~ 81.4 (15°C)
Specific gravity d^{15}_{15}		0.814 ~ 0.816	Less than 0.797	0.860 ~ 0.873
Properties		Colorless, clear with peculiar odor and burning taste.	The same with the left.	The same with the left.
		Miscible with water, ether or chloroform.	The same with the left.	Miscible with water.
		Readily flammable, when ignited, burns with a blue flame.	The same with the left.	When ignited, burns with a light blue flame.
		Volatile	The same with the left.	The same with the left.
		—	Boiling point: 78~79°C	—
Identification test		(1) To 1 mℓ add 2 mℓ iodine solution and 1 mℓ sodium hydroxide solution, and shake, a light yellow precipitate appears. (2) To 1 mℓ add 1 mℓ glacial acetic acid and 3 drops of sulfuric acid, and heat, develops odor of ethyl acetate.	The same with the left.	The same with the left.
Purity test	Solubility	To 10 mℓ add 30 mℓ water, mix at 5 ~ 10°C, allow to stand thirty minutes – clear.	The same with the left.	The same with the left.
	Acid and alkali	To 20 mℓ add 20 mℓ water newly boiled and cooled + 3 drops of phenolphthalein – colorless – 0.10 mℓ sodium hydroxide solution – red color.	The same with the left.	The same with the left.

Purity test	Chloride	To 10 mℓ add 2 drops of dilute nitric acid, 2 drops of silver nitrate solution, allow to stand five minutes – no change.	The same with the left.	The same with the left.
	Heavy metal	(a) To 30 mℓ – 2 mℓ dilute nitric acid + water → 50 mℓ. (b) Standard lead solution (0.01 mg Cu/1 mℓ) 3.0 mℓ – 2 mℓ dilute acetic acid + water → 50 mℓ. Both – add one drop of sodium sulfate solution, mix, – (a) does not develop deeper color than (b) (Less than 1.2ppm in terms of Pb)	The same with the left.	The same with the left.
	Fusel oil and similar impurities	To 10 mℓ add 5 mℓ water + 1 mℓ glucerol – The 0.3 mℓ is dropped on odorless paper – normal temperature, all to stand and to volatilize – no off-flavor remains. Put 5 mℓ carefully into the test tube containing 5 mℓ sulfuric acid – no pink color develops on contact laminating.	The same with the left.	The same with the left.
	Aldehyde and other reducing substances	To 10 mℓ add 0.30 mℓ 0.1N potassium permanganate solution at 15°C, allow stand for twenty minutes. – Red color remains. Also, to 10 mℓ add 5 mℓ solution of sodium hydroxide (0.2N), allow to stand for five minutes – the solution does not develop a yellow color.	The same with the left.	The same with the left.
	Ketone isopropanol, tertiary butanol	To 1 mℓ + 4 mℓ water + 10 mℓ sulfuric acid mercuric solution (5g yellow color oxidation + 40 mℓ water + 20 mℓ sulfuric acid), heat for three minutes in water-bath – no precipitate develops.	The same with the left.	The same with the left.
	Methanol	All to stand for 30 minutes at normal temperature according to the analytical method of the monopoly alcohol standards. The color developed by test solution is not deeper than standard methanol solution A.	The same with the left.	The same with the left.
	Residue on evaporation	To 40 mℓ – evaporate in water-bath, dry the residue for one hour at 105°C – the quantity is less than 1.0 mg.	The same with the left.	The same with the left.

Storage: Ethanol should be put into an airtight vessel by shutting out the light and be preserved by keeping the inflammables away.

Table 2. Standards on Ethyl Alcohol

(i) Standards on monopoly alcohol

As of September 1, 1985 (The last revision: September 6, 1984)

Test item	Indicating unit	Fermented alcohol			Synthetic alcohol	
		Unhydrous, first grade	Hydrous, special grade	Hydrous, first grade	Unhydrous	Hydrous
Properties	—	Colorless, clear, contains no suspended matter, no off-flavor	Colorless, clear, contains no suspended matter, no off-flavor	Colorless, clear, contains no suspended matter, no off-flavor	Colorless, clear, contains no suspended matter. no off-flavor	Colorless, clear, contains no suspended matter. no off-flavor
Ethyl alcohol	Capacity %	More than 99.5	More than 95.0	More than 95.0	More than 99.5	More than 95.0
Residue on evaporation	mg/100mℓ	Less than 2.5	Less than 2.0	Less than 2.5	Less than 2.5	Less than 2.5
Free acid	Weight % in terms of acetic acid	Less than 0.002	Less than 0.002	Less than 0.002	Less than 0.002	Less than 0.002
Aldehyde	mg/100mℓ in terms of acetaldehyde	Less than 0.5	Less than trace	Less than 0.5	Less than 0.5	Less than 0.5
Methyl alcohol	mg/mℓ	Less than 1	No detection made	Less than 1	Less than 1	Less than 1
Diacetyl	Detection or no detection	No detection	No detection	No detection	—	—
Fusel oil	Weight %	Less than 0.004	No detection	Less than 0.004	—	—
Organic impurities	—	No fading from the standard color within four minutes	No fading from the standard color within nine minutes	No fading from the standard color within four minutes	No fading from the standard color within four minutes	No fading from the standard color within four minutes
Sulfuric acid coloration	Detection or no detection	No detection	No detection	No detection	No detection	No detection
Heavy metal	Detection or no detection	No detection	No detection	No detection	No detection	No detection
Chloride	Detection or no detection	No detection	No detection	No detection	No detection	No detection
Sulfate	Detection or no detection	No detection	No detection	No detection	—	—
Sodium hydroxide coloration	Detection or no detection	No detection	No detection	No detection	No detection	No detection
Benzene	—	Less than the standard liquid coloration	—	—	Less than the standard liquid coloration	—
Ketone, isopropyl alcohol, tertiary alcohol	—	—	—	—	Less than the standard liquid coloration	Less than the standard liquid coloration
Normal pentane	—	—	—	—	No normal pentane odor	—
Cyclohexane	—	No cyclohexane odor	—	—	—	—

Note: Test method is based on the V-3 monopoly alcohol test method.

(ii) Japan Industrial Standard

(A) Ethanol (reagent) JIS-K-8101 and JIS-K-8102 (1981)

Grade / Item	Ethanol (99.5)		Ethanol (95)	
	Special grade	First grade	Special grade	First grade
Water soluble	Within limits	Within limits	Within limits	Within limits
Specific gravity	Less than 0.793	Less than 0.793	0.810 – 0.813	0.810 – 0.813
Moisture %	Less than 0.4	Less than 0.4	—	—
Nonvolatile matter	Less than 0.001	Less than 0.003	Less than 0.001	Less than 0.003
Acid	Within limits (Less than about 0.002% in terms of CH_3COOH)	Within limits (Less than about 0.002% in terms of CH_3COOH)	Within limits (Less than about 0.002% in terms of CH_3COOH)	Within limits (Less than about 0.002% in terms of CH_3COOH)
Alkali	Within limits (Less than about 0.0001% in terms of NH_3)	Within limits (Less than about 0.0001% in terms of NH_3)	Within limits (Less than about 0.0001% in terms of NH_3)	Within limits (Less than about 0.0001% in terms of NH_3)
Heavy metal (in terms of Pb)%	Less than 0.0001	Less than 0.0002	Less than 0.0001	Less than 0.0002
Aldehyde and ketone	Within limits (Less than about 0.001% in terms of CH_3COCH_3)	Within limits (Less than about 0.001% in terms of CH_3COCH_3)	Within limits (Less than about 0.001% in terms of CH_3COCH_3)	Within limits (Less than about 0.001% in terms of CH_3COCH_3)
Fusel oil (in terms of $C_5H_{12}O$)	Less than 0.004	Less than 0.004	Less than 0.004	Less than 0.004
Methanol (CH_3OH)%	Less than 0.02	Less than 0.1	Less than 0.02	Less than 0.1
Benzene and other organic impurities	Within limits (Less than about 0.005% in terms of C_6H_6)	Within limits (Less than about 0.005% in terms of C_6H_6)	Within limits (Less than about 0.005% in terms of C_6H_6)	Within limits (Less than about 0.005% in terms of C_6H_6)
Permanganic acid reducing matter	Within limits	Within limits	Within limits	Within limits
Acid wash colored matter	Within limits	Within limits	Within limits	Within limits
Content (by specific gravity) v/v%	More than 99.5	More than 99.5	94.9 ~ 95.7	94.9 ~ 95.7

Note: Alcohol Handbook

5. Process

The production of alcohol is roughly classified into four sections: The raw material treatment section, fermentation section, distillation section and sewage treatment section. The process in the raw material treatment section differs greatly according to the raw material to be used. Glucose material can be fermented by adjusting the concentration of sugar, while in the case of starch material, it is necessary to convert starch into glucose in the beginning.

There are various processes, but here a typical, basic process will be shown.

5.1 Raw Material Treatment Section

(1) In the case of glucose material

(a) In case sugar cane juice is used

As the sugar cane juice has the sugar concentration of about 15wt%, it can be fermented as it is. However, in the case of the process, where yeast is reused first of all to remove sludge.

(b) In case molasses is used

As molasses is a by-product, which is generated in the manufacture of sugar, its sugar concentration is about 50wt%. Molasses being high in sugar concentration, its viscosity is too high to ferment it as it is. The simplest process is to dilute with the water concentration of sugar down to the extent that yeast can easily digest it. However, as it contains a fairly large quantity of impurities and non-fermentable sugar, its fermentation yield is not so good. Since the composition varies according to the place of origin, it needs to adjust the auxiliary material so that fermentation can be done efficiently. In some processes molasses is heated or treated with acid to raise the yield, but in this brochure a simple process will be adopted. Fig. 1 shows its process flow sheet.

(2) In the case of starch material

Fig. 2 shows a basic process flow sheet, where starch is used as raw material. The raw material is first broken fine and is heated with water at a temperature higher than 130°C, and is cooked for over five minutes. And when the temperature comes down to 95°C or so, liquefaction enzyme is added. And then saccharification enzyme is added when the temperature comes down to about 55°C, and then the temperature is reduced to some 30°C. The liquid thus made becomes the raw material of fermentation.

On one hand, the newly developed process, which is shown in Fig. 3, is attaining the same or better yield than the previous one using enzyme at a temperature under 80°C. As the process uses a lower temperature, the quantity of steam consumed is about a half of the conventional process. From now on, this process will come to be adopted. The latest process shown in Fig. 4 is a non-cooking process, in which the raw material is broken fine, to which special enzyme is added, and by the addition of yeast thereto alcohol fermentation is achieved. Although the process is simple, it needs to import special enzyme for use.

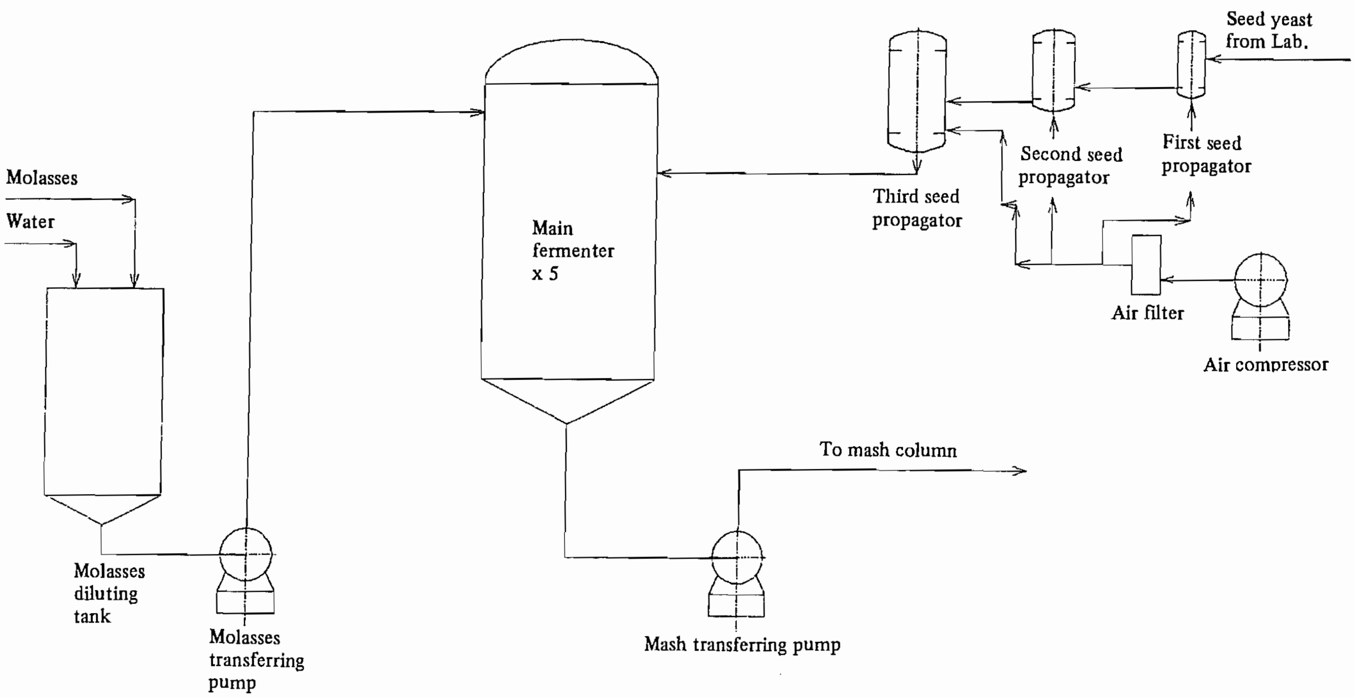

Fig. 1 Flow Sheet of Fermentation Process

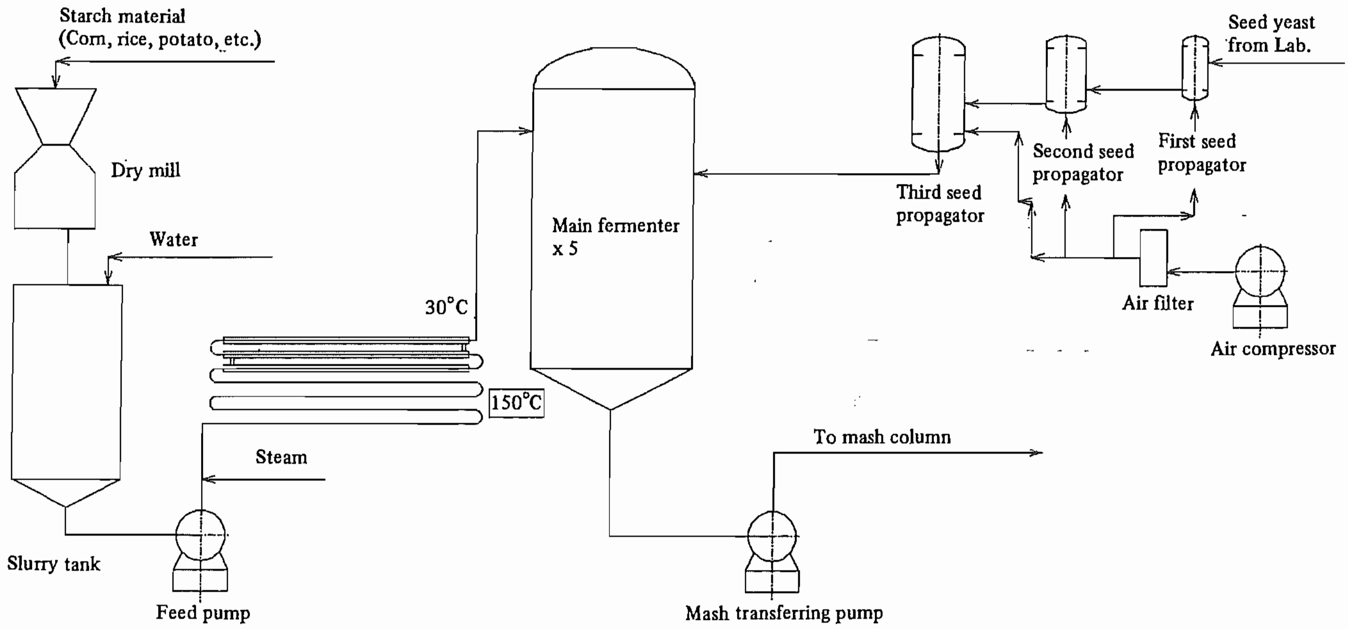

Fig. 2 Flow Sheet of Starch Fermentation Process (Conventional Cooking System)

5.2 Fermentation Section

(a) Propagation of seeds

There are many kinds of yeast which are used for ethanol fermentation, which necessitates the selection of yeast which is suitable for each raw material. As yeast is classified according to the raw material it fits well, it is important to pick up a suitable yeast and propagate it purely to raise the yield. This is applicable both to the use of glucose material and starch material. Fig. 5 shows the propagation process of seeds.

The yeast to be used for ethanol fermentation must be produced each time according to the method mentioned below. First, the yeast preserved in the laboratory is propagated in a triangle flask at a temperature of about 30°C using the aforesaid raw material under the condition of no microorganisms. In the next stage the yeast is propaged in the pure culture fermenter of 50~90 liters. The raw material shown in the foregoing paragraph is used. The temperature is controlled at 30°C, and the sterilized air is supplied to produce yeast. Using the yeast thus made as seeds, the same process is repeated in a pure culture fermenter having the capacity 10 to 20 times as much as that. Finally, the pure yeast of one tenth to one twentieth of the capacity of the ethanol fermenter is produced.

(b) Ethanol fermentation

The raw material, which was prepared in the raw material treatment section, is kept at a temperature of 30~35°C. Depending on the raw material, auxiliary raw materials are added to make up for a short component. The pure yeast prepared is put into the fermenter and then raw material is added. Fermentation generally terminates in three to four days according to the raw material to be used. In case the sugar concentration of raw material is low, the fermentation hour is short, but the concentration of alcohol to be produced is also low. Hence, it is necessary to adopt the optimum condition while studying the concentration and the time. In the beginning of fermentation, carbon dioxide gas is heavily generated, but as the fermentation nears the end, the gas comes out scarcely. The concentration of alcohol should be checked from time to time so as to determine the end of fermentation. The final concentration depends on the sugar concentration of raw material, but it generally is 8~10 vol%.

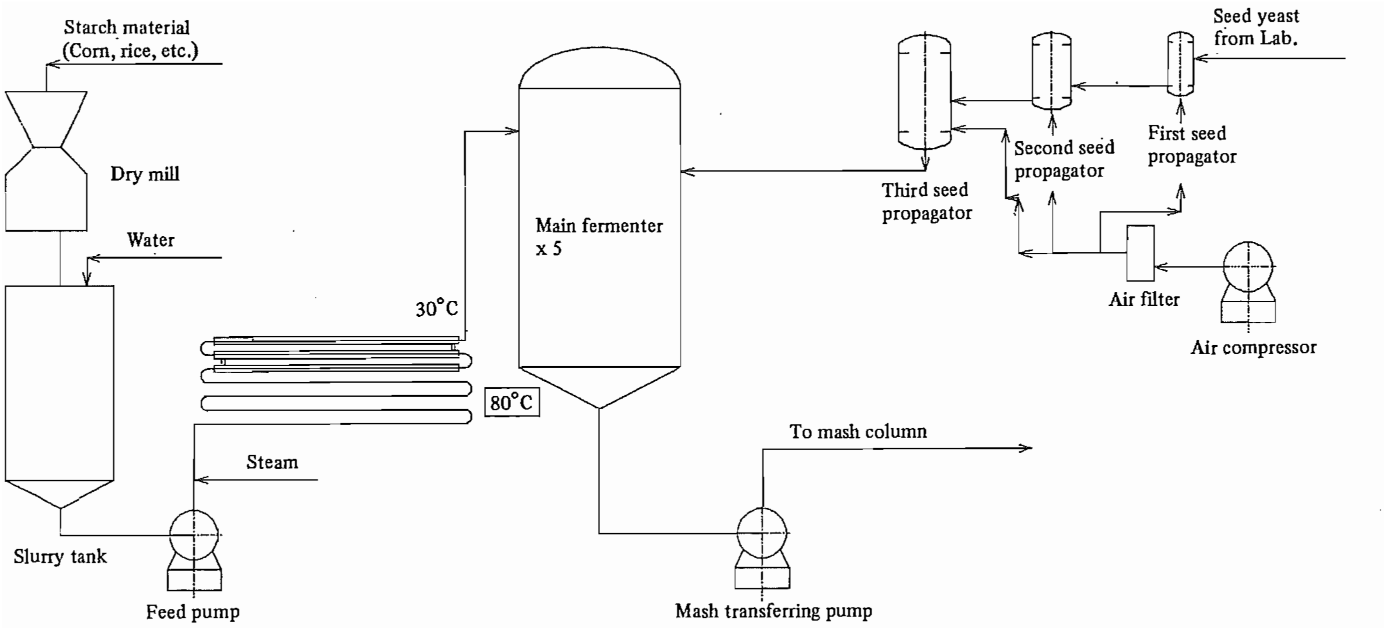

Fig. 3 Flow Sheet of Starch Fermentation Process (Low Temperature Cooking System)

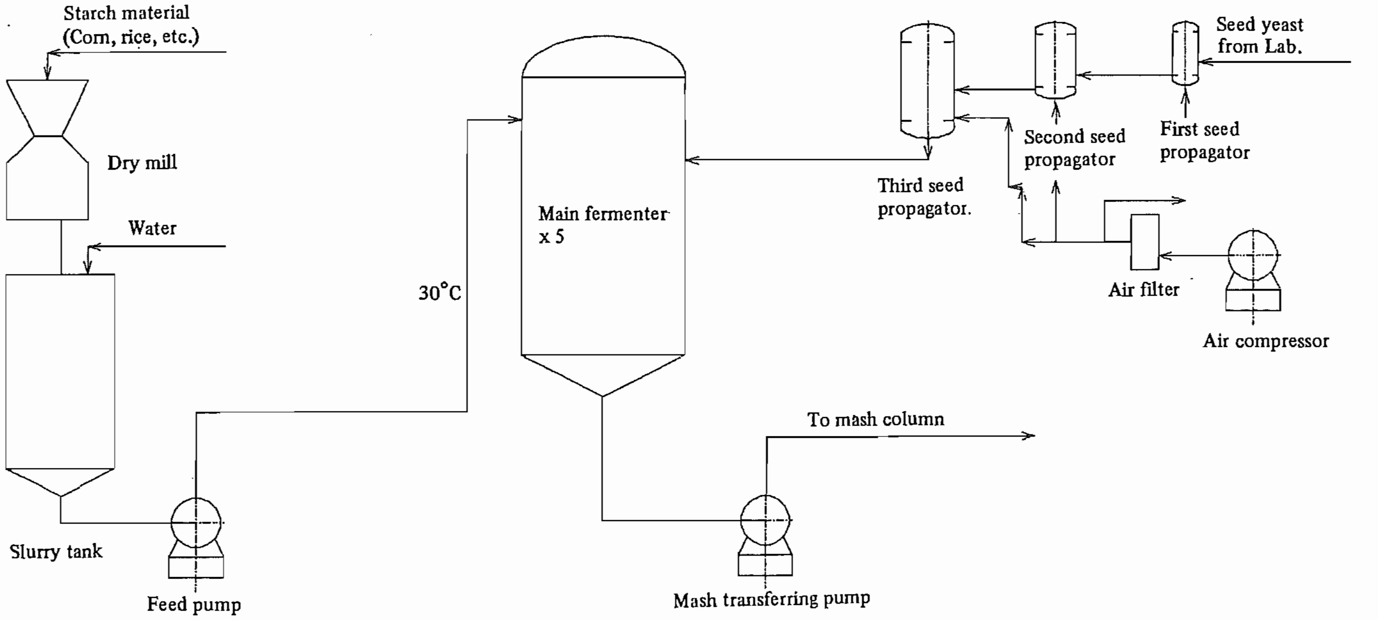

Fig. 4 Flow Sheet of Starch Fermentation Process (Non Cooking System)

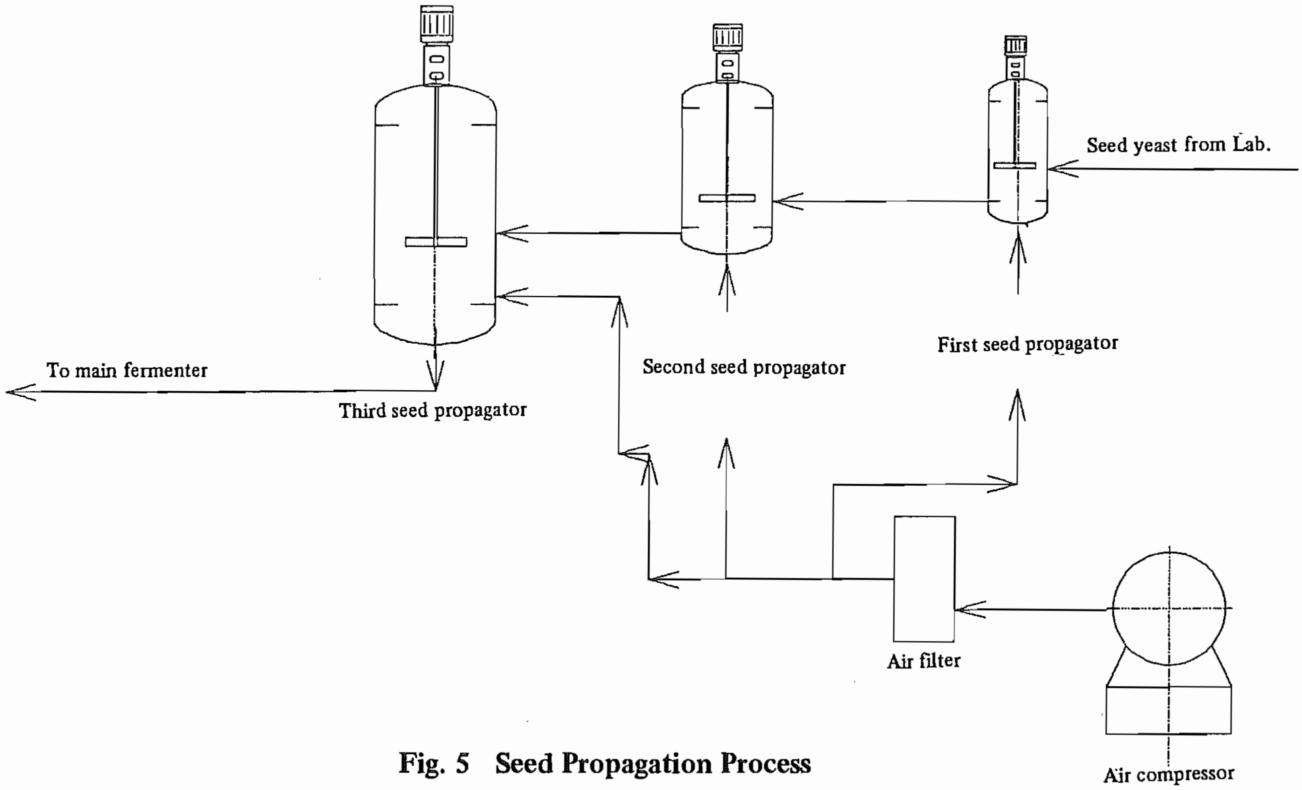

Fig. 5 Seed Propagation Process

The flow sheet of the process which was adopted in this brochure is shown in Fig. 1.

In the following distillation process, the raw material is concentrated to 96 vol%. Researches on concentration are being made using membrane, but it has not yet been put into practice.

5.3 Distillation Section

The 8~10 vol% fermented alcohol solution is transferred to a mash column, where the solution is concentrated to about 50% concentration, and is transferred to the following rectifier. As the fermented alcohol contains various impurities, they must be removed. Aldehyde, etc. is removed in the mash column, and fusel oil and methanol in the rectifier. Although some impurities exist in the product coming from the rectifier, it can be used for industrial and medical purposes. In order to further refine the product, it needs to install an

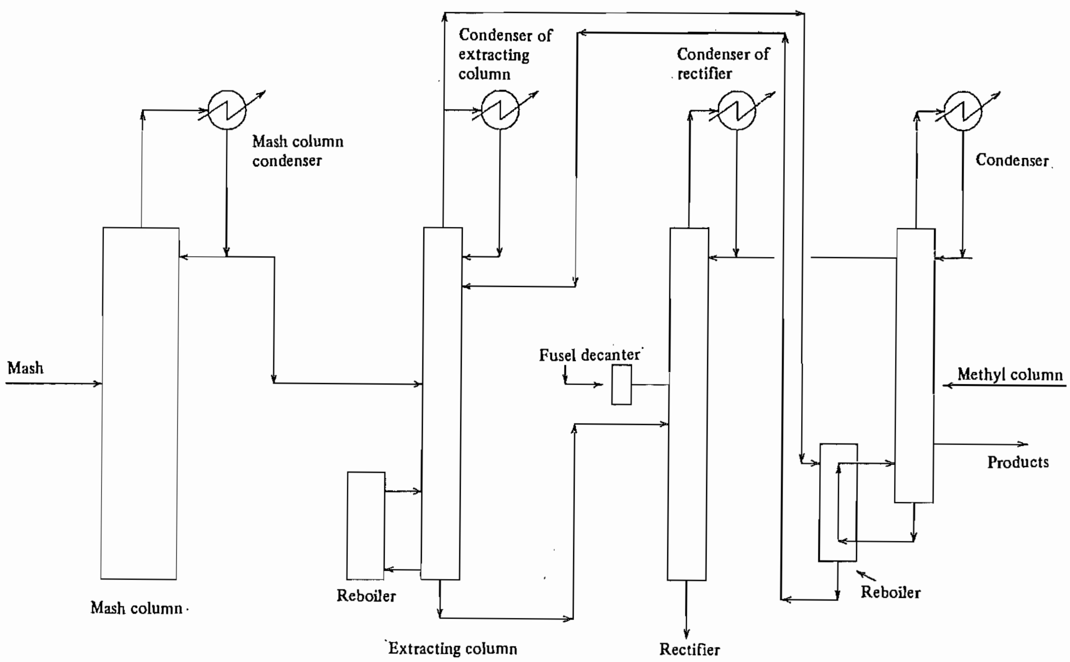

Fig. 6 Flow Sheet of Distillation Section

extracting column and an impurity recovery column. Methanol and aldehyde are furthermore eliminated in the extracting column. The alcohol concentration to be obtained in the distillation process is 96vol%. In case the alcohol of more than 99.5vol%, which is called absolute alcohol, is put out, it is necessary to install, next to the mash column and the rectifier, a dehydrator which uses benzene or cyclohexane. And the azeotropic mixture of water, alcohol and benzene (or cyclohexane) is made so as to separate water and alcohol. As the separated water contains alcohol and benzene (or cyclohexane), it is necessary to recover benzene (or cyclohexane) by distilling the water. Fig. 6 shows the flow sheet of the process, which was adopted in this brochure.

5.4 Sewage Treatment Section

The waste water discharged from the distillation process is of low pH value and contains protein, non-digested glucose, and the body of yeast. This usually is equivalent to about 30,000 ppm of BOD. In the case of using glucose material, waste water is disposed of after treatment by activated sludge process in Japan. The sludge is concentrated and dried to be used as solid fertilizer. In Brazil the sludge is kept in a pond and is sprinkled over the field in terms of liquid fertilizer at a proper time.

In the case of using starch material, in which corn, for example, is used as raw material, nutrient still remains in the solid part, and liquid and solid are separated by centrifugal separator, and the solid is used as an animal feed. As the liquid is of low pH value, it is drained into a river after being treated by the activated sludge process. In some countries the sludge is kept in a shallow pond to dry in the sun, and the solid part is spread over the field.

6. Outline of a Model Plant

In this brochure molasses will be used as raw material to produce ethanol for medical use by the process described in the preceding paragraph.

6.1 Plant Scale

The plant scale should be selected according to the actual condition of a country concerned. As to the type of operation, it is necessary to conduct a 24-hour continuous operation from the point of profitability.

In this brochure the plant scale will be fixed at 10 kℓ/day.

6.2 Plant Operation

(1) The annual number of operating days is 300 days.
(2) The number of working hours is 24 hours/day.
(3) The annual output is: 10 kℓ x 300 days = 3,000 kℓ/year.

6.3 Required Quantity of Raw Material

Molasses is used. As the fermentable glucose is about 50%, some 3.6 tons of molasses are necessary for the production of 1 kℓ ethanol.

Accordingly, the annual required quantity of molasses is 3.6 tons/kℓ-ethanol x 3,000 kℓ = 10,800 tons/year.

6.4 Utilities

As utilities, electricity, water, and steam are necessary. The quantity needed for each of them is as below.

Electricity	100 kWh/kℓ-ethanol
Water	10 tons/kℓ-ethanol
Fuel oil	200 ℓ/kℓ-ethanol

6.5 List of Main Machinery and Equipment

(a) Raw material treatment section

Name	Specification	Quantity
Molasses storage tank	1,200 kℓ	1
Molasses transferring pump	10 kℓ/hr	1
Molasses diluting tank	120 kℓ	2

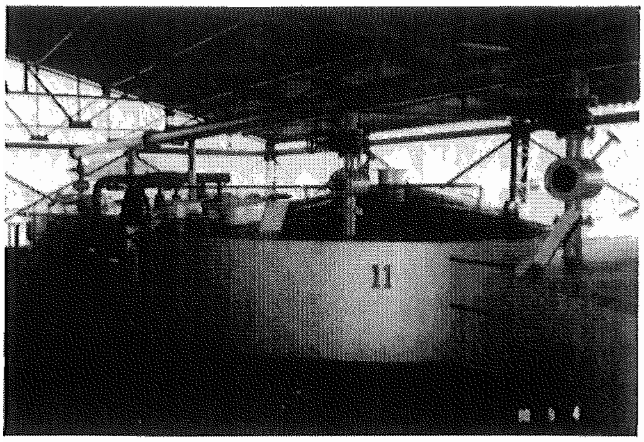

Photo 2. Fermenter

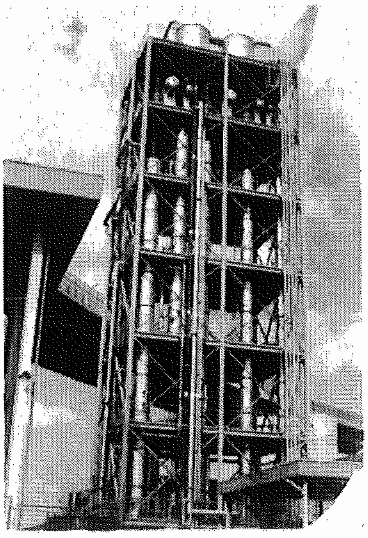

Photo 3. Rectifier

(b) Fermentation section

Name	Specification	Quantity
Seed fermenter	50 ℓ	1
Second seed fermenter	1 kℓ	2
Third seed fermenter	10 kℓ	2
Main fermenter	120 kℓ	5
Mash transferring pump	10 kℓ/hr	2
Air compressor	2.5m^3/min	1
Air filter	2.5m^3/min	1

(c) Distillation section

Name	Specification	Quantity
Mash column	ϕ1,000 x 20	1
Condenser of mash column	20m^2	1
Rectifier	ϕ 800 x 60	1
Condenser of rectifier	40m^2	1
Extracting column	ϕ 800 x 50	1
Condenser of extracting column	30m^2	1
Reboiler of extracting column	15m^2	1
Methyl column	ϕ 300 x 30	1
Condenser of methyl column	10m^2	1
Reboiler of methyl column	8m^2	1
Decanter of fusel oil	ϕ400 x 1,000	1
Pump	5m^3/hr	4

(d) Utilities section

Name	Specification	Quantity
Cooling tower	50 tons/hr	1
Cooling water pump	50 tons/hr	1
Boiler	1 ton/hr	1
Cooling water recycling pump	50 tons/hr	1
Fusel oil tank	10m^3	1
Storage tank of products	150m^3	1

(e) Sewage treatment section

Name	Specification	Quantity
Blower	100 m^3/hr	1
Pump		1

6.6 Machinery and Equipment Cost

	US$
Raw material section	100,000
Fermentation section	700,000
Distillation section	600,000
Sewage treatment section	200,000
Utilities section	500,000
Tanks	400,000
Total US$	2,500,000

Note: 1. The cost of machinery and equipment is shown by FOB Japan 1988.
2. Exchange rate: US$1 = ¥130

6.7 Plant Layout

Fig. 7 shows the plant layout.

6.8 Area of Plant and Building

(1) Area of plant: 100m x 200m = 20,000m^2

(2) Buildings

Factory	800m^2
Warehouse	1,000m^2
Office	200m^2
Total	2,000m^2

6.9 Required Number of Workers and Placement

Table 3 shows the required number of workers and placement.

Table 3. Required Number of Workers and Placement

	Number of worker	Shift	Total number of workers
Factory manager	1	1	1
Raw material treatment section	1	3	3
Fermentation section	1	3	3
Distillation section	1	3	3
Sewage treatment section	1	3	3
Utilities section	1	3	3
Quality control section	1	1	1
Total			17

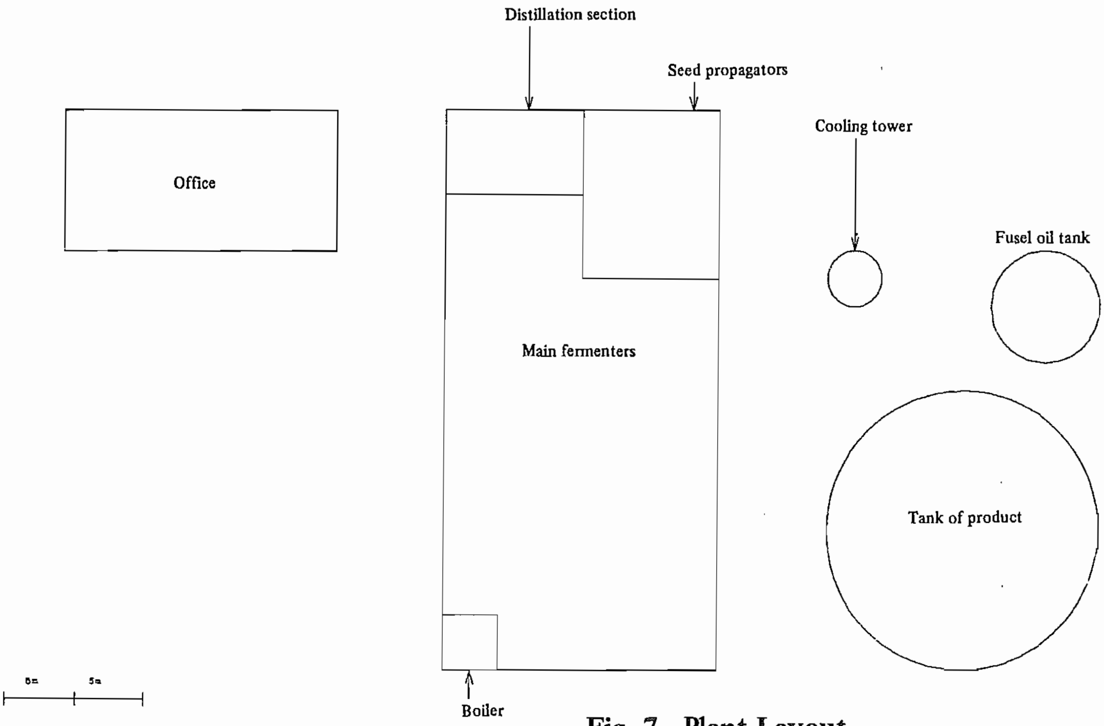

Fig. 7 Plant Layout

7. Production Cost and Profitability

In order to estimate the profitability of an ethanol manufacturing plant, it is necessary to calculate the production cost. As the raw material cost and labor cost vary according to a country concerned, the calculation was made in this brochure on the basis of the conditions cited below.

7.1 Basic Conditions for Calculation

(1) Fixed capital

(a) No land price was included. However, it is necessary that the ground is not soft, and has such bearing capacity that a heavy weight plant can be built thereon.

(b) The construction cost of office, factory and warehouse is supposed to be US$ 250/m^2.

(c) The cost of machinery and equipment is FOB Japanese port. However, no import duty is levied on the machinery and equipment.

(d) The spare parts cost is assumed to be 8% of the FOB price of machinery and equipment.

(e) Freight and insurance cost is assumed to be 5% of the FOB price of machinery and equipment.

(f) Civil engineering cost is assumed to be 5% of the FOB price of machinery and equipment.

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

(h) Supervision and guidance fee is assumed to be 5% of the FOB price of machinery and equipment.

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

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

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

(2) Working capital

Raw material cost	for 30 days
Products inventory	for 15 days

(3) Production cost

(a) Raw material cost

Molasses price fluctuates fairly, but it was set at US$40/ton on the basis of the current international price. The quantity to be used differs depending on the concentration of fermentable sugar. In case the concentration is supposed to be 50%, it needs molasses of about 3.6 tons/kℓ-ethanol.

(b) Unit price of utilities

Electricity	US$0.06/kWh
Industrial water	US$0.2/ton
Fuel oil	US$200/kℓ

(c) Labor cost

The annual labor cost is assumed to be as follows.

Factory manager	US$14,000
Engineer	US$ 8,000
Skilled worker	US$ 4,000
Unskilled worker	US$ 2,000
Odd-job man	US$ 500

(d) Maintenance cost

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

(e) Depreciation cost

Straight-line method was adopted. The depreciation cost was calculated according to the formula shown below.

Machinery and equipment:
(Fixed capital – building construction cost) x 7%
Building:
Building construction cost x 3%

(f) Insurance cost

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

(g) Selling and administration expense

Selling and administration expense is assumed to be 2% of the annual sales revenue.

(h) Interest

Fifty percent of the fixed capital is covered by equity capital and the remaining 50% by a long-term loan with a 10% rate of interest.

(i) Exchange rate

The exchange rate of the US dollar to the Japanese Yen is assumed to be US$ 1 = ¥130.

7.2 Annual Sales Revenue

The selling price of ethanol for medical use was set at US$700 per kiloliter on the basis of international price. The number of operating days is 300 days a year, and 3,000 kℓ/year is put out, which will bring about US$2,100,000 by way of the annual sales.

7.3 Capital Required

(1) Fixed capital

	US$
Land	Not included
Factory building	500,000
Machinery and equipment (FOB Japan)	2,500,000
Spare parts	200,000
Freight and insurance	125,000
Erection work	250,000
Civil engineering work	125,000
Supervision and guidance fee	125,000
Commissioning cost	75,000
Training cost	75,000
Contingency	250,000
Subtotal US$	4,225,000

(2) Working capital

Raw material cost	US$43,200
Products inventory	US$47,140
Subtotal US$	90,340

(3) Capital required (1) + (2) US$ 4,315,340

7.4 Production Cost

The annual production cost is as follows.

(a) Raw material cost US$432,000
(US$40/ton x 10,800 tons/kℓ-ethanol.)

(b) Utilities cost US$144,000
Electricity US$ 18,000
(US$0.06/kWh x 300,000 kWh)
Industrial water US$ 6,000
(US$0.2/ton x 30,000 tons)
Fuel oil US$120,000
(US$200/kℓ x 600 kℓ)

(c) Labor cost

Factory manager	US$14,000 x 1	US$14,000
Engineer	US$ 8,000 x 1	US$ 8,000
Skilled worker	US$ 4,000 x 6	US$24,000
Unskilled worker	US$ 2,000 x 6	US$12,000
Odd-job man	US$ 500 x 3	US$ 1,500
	Subtotal	US$ 59,500

(d) Maintenance cost	US$ 75,000
(e) Depreciation cost	US$ 275,750
(f) Insurance cost	US$ 21,130
(g) Selling and administration expense	US$ 42,000
(h) Interest	US$ 211,250
Total	US$1,260,630

7.5 Profitability of the Plant

The following shows the result of the study on the profitability of a plant putting out 10 kℓ/day. The annual sales is US$2,100,000, and the cost spent for which is US$1,260,630, and the profit will be US$839,370.

Ratio of profit to sales revenue:
US$839,370/US$2,100,000 x 100 = 40.0%
Ratio of profit to capital required:
US$839,370/US$4,315,340 x 100 = 19.5%

As was shown above, the profit ratio to sales is 40.0%, and the profit ratio to capital required is 19.5%. It is considered that the profitability is good.

8. Conclusion

Ethanol for medical use is indispensable to the people's living. As was mentioned earlier, there are many raw materials which can be used for manufacturing alcohol. But in this brochure molasses, which is obtainable comparatively easily, was taken up as raw material. There are many utilizing methods of ethanol. Ethanol is one of the important, basic raw materials. It may be necessary to set up the system of this plant as soon as possible. The project may be very beneficial to the countries that are importing alcohol but are blessed with raw material resources.

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
No. 26 Manufacturing Plant of Ethanol for Medical Use

Project Planning for Small and Medium Scale Industries No. 26

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