

"PLANT FOR PRODUCTION OF PROPANE-AIR GAS"

This invention relates to a plant for the production of city gas, and particularly to a plant for producing propane-air gas, or propane diluted with air.

5 Heretofore, plants for producing city gas have been available in varied forms: catalytic cracking plants using naphtha or butane as raw material, coal gas plants operating on coal or coke feed, butane-air plants mixing and diluting butane with air, liquified natural
10 gas (LNG) plants and so forth.

Catalytic cracking plants convert naphtha or butane to methane, hydrogen, carbon monoxide, and carbon dioxide by reaction of the feedstock with steam using a catalyst at a reaction temperature of 400° to
15 800°C.

Coal gas plants involve reaction of raw material coal or coke with air or steam as a gasifying agent to decompose the material into hydrogen, methane, carbon dioxide, and the like. In the process for gas
20 production the plants form four distinct zones; preheating (dry distillation), reduction, oxidation, and ash zones.

Butane-air plants vaporize butane by means of vaporizers that depend on electricity, hot water,
25 steam or the like for the supply of thermal energy, and

mix and dilute the gasified butane with air by mixers to obtain a gaseous mixture of desired heating value.

LNG plants receive natural gas, liquified at very low temperatures into a cryogenic storage facility, vaporize it by LNG vaporizers, and adjust the gasified natural gas to a desired heating value for supply to the consumers.

The existing plants for city gas production have many different problems yet to be solved.

10 The catalytic cracking plant, which gasifies naphtha or butane feedstock, produces gas containing as much as 12 to 20% carbon monoxide. Although the content is decreased subsequently by CO modification in an effort to avoid poisoning, a tiny percent of carbon
15 monoxide is left unremoved in the gas supply. At the present time complete elimination of fatalities from the gas poisoning is still infeasible.

In addition, the catalytic cracking plant includes gas and air blowers, pumps, and other
20 components as sources of vibration and noise. In order to avoid possible public nuisances, the vibration and noise must be controlled with no small expenditures of money. Also, waste water from the plant is a potential source of pollution and must be monitored with caution.
25 Gas blow during the process for production necessitates

countermeasures to combat the offensive smell of the gaseous emissions and their deleterious effects upon the environment. Furthermore, the gas manufactured by such a plant, wet by nature, tends to be reliquified.

- 5 Owing to this physical tendency, the gas can clog distribution lines with water collection in the lines and gas meters and pose many other problems including freeze choking of gas meters in winter and gas leakage due to internal corrosion of the lines with moisture.
- 10 To preclude these, periodical draining and inspection of the lines have been required at considerable personnel and maintenance costs.

The coal gas plant, handling bulky coal or coke as the raw material, necessitates a large storage
15 area and huge equipment.

- The butane-air gas system needs electricity, hot water, steam, or other thermal energy to gasify butane. Inevitably the equipment has some fire source in itself and always has an ignition or explosion
20 potential. In fact, there have been not a few cases of hazards, and the system is not desirable from the safety viewpoint. Moreover, the electric, hot water, and steam heat sources require boilers, pumps, and other auxiliary units the maintenance of which is a
25 necessary and important routine. In terms of labour,

energy, and financial requirements, the maintenance is a great burden, notably on minor gas utilities.

The LNG plant receives natural gas cooled down to -162°C into a cryogenic storage facility, vaporizes it by an LNG vaporizer, and adjusts its calorific value to 11000 kcal/Nm^3 before its supply to the consumers. The system thus calls for special storage and auxiliary equipment and special receiving and transporting facilities. The requirement for gigantic equipment and huge investment have limited the owners of such plants to big gas utility companies. The plant, which handles LNG that boils at -162°C , presents unusual technical problems, demanding great skill and care in operation.

As stated above, the gas-producing plants of the prior art have involved large-scale equipment, complex heat-source components, and power drives and have necessitated much labour and cost for construction, maintenance, and control for safety.

Besides, it is to be noted that the city gas in use in Japan is classifiable into a great variety of types as listed in Table 1. The variety is causing extreme inconvenience to the consumers, gas appliance manufacturers, and gas utilities alike.

Table 1

5	Designation of gas type	Wobbe Index WI*	Gas pressure (mmH ₂ O)		
			Maximum	Standard	Minimum
	13A	13800-12600	250	200	100
	12A	12850-11750	"	"	"
	11A	12000-11000	"	"	"
	6A	6700 - 5680	220	150	70
10	5A	5400 - 4700	200	100	50
	5AN	4970 - 4320	"	"	"
	4A	4280 - 3720	"	"	"
	6B	6850 - 5950	"	"	"
	5B	5350 - 4650	"	"	"
15	4B	4330 - 3770	"	"	"
	7C	7060 - 6140	"	"	"
	6C	6530 - 5670	"	"	"
	5C	5890 - 5110	"	"	"
	4C	4550 - 3950	"	"	"

20 * WI = Calorific value of the gas/($\sqrt{\text{sp. gr. of the gas}}$).

For this reason efforts are being made by the Ministry of International Trade and Industry (MITI) to standardize and unify the gas types available.

Accordingly, it is a principal object of this
25 invention to provide a plant for the production of

propane-air gas with good safety features.

The present invention is a plant for the production of propane-air gas characterized by a storage tank for storing liquified propane gas, an air-heated type vaporizer for vaporizing the liquified propane gas from the storage tank, an air mixer for mixing and diluting the propane gas vaporized by the air-heated type vaporizer with air, and calorific-value-adjusting means having a calorimeter and a mixing-air flow regulator, said calorific-value-adjusting means recovering part of the propane-air gas emerging from the air mixer, through a line connecting the calorific-value-adjusting means with the air mixer, and determining the calorific value of the recovered propane-air gas by means of said calorimeter, the determined value being used in the manual or automatic control of the quantity of air to be admitted to the air mixer by means of said mixing-air flow regulator.

The present invention is also a plant for the production of propane-air gas characterized by a storage tank for storing liquified propane gas, an air-heated type vaporizer for vaporizing the liquified propane gas from the storage tank, an air mixer for mixing and diluting the propane gas vaporized by the air-heated type vaporizer with air, a gas holder for storing the propane-air gas emerging from the air mixer, an air mixer control means for controlling the operation of the air mixer according to the gas quantity inside the gas holder, and calorific-value adjusting means for recovering part of the propane-air gas emerging from the air mixer, and determining the calorific value thereof, the determined value being used in the manual or automatic control of the quantity of air to be admitted to the air mixer.

Specific embodiments of the present invention will now be described by way of example and not by way of limitation with reference to the accompanying drawings, in which:-

Fig. 1 is a flowsheet of a propane-air-gas-producing plant embodying the invention;

Figs. 2 and 3 are front elevational and top views, respectively of the air-heated type vaporizer;

5 Fig. 4 is a schematic view of the air mixer; and

Figs. 5 and 6 are longitudinal and cross sectional views, respectively, of the double-pipe line.

Referring to the accompanying drawings, Fig. 1 is a flowsheet of a plant for the production of propane-air gas embodying the invention. According to the invention, liquified propane gas L introduced into the plant 1 by given transportation means is stored in a storage tank 2 installed within the plant. The liquified propane gas L in the storage tank 2 is fed through line 4 to control boxes 6 (6a, 6b, and 6c), where the gas pressure is lowered. The liquified propane gas L under reduced pressure is fed through lines 8 to vaporizers 10 (10a, 10b, and 10c) to be vaporized there.

For the purposes of the invention, the vaporizers 10 to be used are air-heated (atmosphere-heated) type forced vaporizers. They adopt the fin-and-tube system and, as shown in Figs. 2 and 3, each of them has an inlet manifold 12 and an outlet manifold 14, interconnected with a number of heating tubes 16 in between. Each tube 16 is provided with a plurality of heating fins 18 attached thereon for enhanced heat transfer efficiency. Thus, the liquified propane gas L fed through lines 8 to the vaporizers 10 flows into their inlet manifolds 12 and then passes through the heating

tubes 16 into the outlet manifolds 14. During this, the liquified propane gas L is vaporized by the combined heat transfer action of the tubes 16 and fins 18 to form propane gas G.

5 The propane gas formed by the vaporizers 10 is transferred through lines 20 to air mixers 22 (22a, 22b, and 22c). The gas G is mixed and diluted with air by the mixers to prepare a propane-air mixture of a desired calorific value, or propane-air gas PG of Type 13A with
10 a calorific value of 15000 kcal/Nm^3 . The calorific value is the same as that of city gases being produced by big LNG plants in large cities and enables this propane-air gas PG to be used by appliances common to the latter, offering much convenience to the general
15 consumers. Moreover, the manufacture of such gas is desirable as it complies with the administrative policy of MITI to standardize and unify the city-gas types. This gas is dry and precludes any problem of gas line clogging due to water collection in the lines or gas
20 meters, gas meter freezing in winter, or gas leakage owing to internal corrosion of the piping. Consequently, there is no need of periodic draining or inspection of lines for the prevention of such troubles, and labour and maintenance costs otherwise required for these
25 purposes can be saved.

The air mixers 22 may be of venturi tube, blower, flow-ratio control, or other type. This embodiment of the invention is described as employing the venturi tube type as illustrated in Fig. 4. In each mixer a venturi tube 24 is mounted between line 20 on the inlet side and line 26 on the outlet side. The venturi tube 24 is fed with the propane gas G from the vaporizer 10, at a pressure adjusted from the feed level of 0.7 to 1.0 kg/cm² to a constant pressure, e.g., of 0.7 kg/cm², by a main regulator 25. The supply of propane gas G to the venturi tube 24 minus the discharge therefrom creates a negative pressure high enough to draw air by suction through line 28 into the venturi tube 24, where the propane gas G is mixed with air. The quantity of air thus to be drawn into the venturi tube 24 is controlled by an air control valve 30, mounted on line 28 in the manner to be described later, so that the mixing ratio of propane gas G to air is propane:air = 2:1.

The propane-air gas produced in this way is delivered via line 26 to a gas holder 32 for storage. The propane-air gas PG once stored in the gas holder 32 is then supplied to the consumers with a calorific value of 15000 kcal/m³ at a supply pressure of 250 mmH₂O. The quantity of the propane-air gas PG in the

gas holder 32 is adjusted by controlling the operation of the air mixers 22. Also, the gas volume in the holder is detected by means of a gas volume detector 34 attached to the vessel.

5 The manner in which the plant for the production of propane-air gas built as above is controlled will now be explained.

 Means of controlling the operation and stoppage of the air mixers 22 include the volume detector 34 of
10 the gas holder 32, e.g., a storage-height sensor-oscillator. Electric signals from the volume detector 34 are transmitted through an electric cable E1 to a line-switching controller 102 installed in a central control room 100. The line-switching controller 102 is
15 connected via an electric cable E2 to explosion-proof solenoid valves 27 which control respectively associated main regulators 25 of the air mixers 22 (22a, 22b, and 22c). In response to the direction from the line-switching controller 102, the solenoid valves 27 turn
20 open, allowing compressed air, e.g., at a pressure of 5.5 kg/cm^2 , from a compressed air source 200 to find its way through operating-air lines A1, A2, and A3 into the main regulators 25, forcing their valves open. This permits injection of the propane gas G, gasified by the
25 vaporizers 10, into the air mixers 22. The compressed

air source 200 may be of any desired construction. In a preferred embodiment it comprises an air compressor 202 for supplying air at a given pressure necessary for operating the main regulators 25 and other air control valves, a freezing dehumidifier 204 for removing moisture from the operating air from the air compressor 202, and a receiver tank 206 for storing the operating air at a constant pressure.

In the manner described, the air mixers 22a, 22b, and 22c, are turned on or off by the line-switching controller 102. An example of the controlling operation will now be explained in connection with the present embodiment shown in Fig. 1. The gas holder 32 being assumed to have a capacity of 100 m^3 , the line-switching controller 102 will be actuated upon drop of the gas content in the holder down to 70 m^3 and give a direction to the air mixer 22a for its singular operation. When the gas production by the single-unit operation of the air mixer 22a is insufficient and the stored quantity in the gas holder 32 has decreased to 65 m^3 , the air mixer 22b is directed to work too. When the combined gas production by the air mixers 22a and 22b still fails to catch up with the consumption and the quantity in the gas holder 32 has dwindled to 60 m^3 , the remaining air mixer 22c is directed to join the gas-producing operation.

Conversely, when the gas volume in the gas holder 32 has increased to 80 m^3 , the air mixer 22c is stopped. When the volume has further increased to 85 m^3 and 90 m^3 , the air mixer 22b and then the mixer 22a are
5 stopped, respectively, so that all the air mixers 22 become inoperative.

In the gas-producing plant of the invention, calorific-value-adjusting lines are provided. According to the invention, a Lauter calorimeter 104 is installed
10 in the central control room 100. In order that it may determine the gas calorific values at the outlets of the air mixers 22a, 22b, and 22c and the total calorific value of the gas from these mixers, part of the gas is recovered from lines 26 through branch lines C1 to C4
15 for calorific value determination.

The gas portions recovered in this way are passed through the Lauter calorimeter 104 for calorific value determination. The central control room 100 is equipped also with a mixing-air flow regulator 106, which
20 is connected through electric cables E3, E4, and E5 to electric-air positioners 31 which operate control valves 30 controlling air supply to the air mixers 22. With the arrangements of the construction described, the operator manipulates the mixing-air flow regulator 106
25 in response to the indicated value of the Lauter

calorimeter and allows it to give electric signals to the electric-air positioners 31 via the electric cables E1 to E3. The electric-air positioners 31 convert the signals to air signals with which to control the openings
5 of the air control valves 30. In this way the air supply to the individual air mixers 22 is finely adjusted, and the ratio of air to propane gas in the resulting propane-air gas and hence the calorific value of the product are controlled.

10 While the mixing-air flow regulator 106 has been described as manipulated by an operator, it may instead be interlocked with the calorimeter for automatic operation.

Embodiments of the present invention are character-
15 ized by the construction of the calorific-value-determination lines C1 to C4 for use as calorific-value-adjusting lines. According to the invention, as shown in Figs. 5 and 6, the lines C1 to C4 consist each of a small-diameter inner pipe 40, e.g., of copper, for sample gas recovery,
20 e.g., having an inside diameter of 5 to 8 mm, preferably 6 mm, and wall thickness of 0.8 to 1.2 mm, preferably 1 mm, and a large-diameter, protective outer pipe 42, e.g., of steel, surrounding the inner tube 40, with an inside diameter of 20 to 30 mm, preferably 27.6 mm, and
25 wall thickness of 2 to 5 mm, preferably 3.2 mm. The use

of small pipes, e.g., 6 mm in inside diameter,
in place of the conventional larger pipes,
e.g., of 20 mm diameter, for recovering
and conducting sample gas to the Lauter calorimeter 104
5 makes possible immediate calorific value determination
and adjustment. The time lag of one to two minutes
that has usually been required for the calorific value
determination and adjustment is no longer necessary.
Thus when the plant of the invention is designed for
10 gas production of about 10000 m³/day, for instance, it
is possible to eliminate the gas holder 32 or replace
it by a holder of a far smaller capacity. This
simplifies the plant layout in building a gas-producing
plant and saves largely the site and construction costs.

15 The protective outer pipe 42 surrounding each
inner pipe 40 not merely provides protection but, in
addition, allows flow of warm air in the space between
the inner and outer pipes 40, 42 to keep warm the
sample gas passing through the inner pipe. The heat-
20 retaining effect thus attained assures rapid and
accurate calorific value analysis of the sample gas
irrespective of the ambient temperature.

 The double pipe structure is applicable not
only to the lines C1 to C4 for calorific value
25 determination but to the operating-air lines A1 to A3

as well.

The plant for the production of propane-air gas according to the present invention may be provided with internal safety control valves that work when
5 leakage or other abnormality takes place in the pipelines and other arrangements and also with emergency stoppers to shut off the gas flow in case of serious irregularity of the gas-producing equipment. The central control
10 room for controlling the plant of the invention has graphic panels showing the particulars of plant layout to facilitate precise monitoring of the plant operations.

With the construction described above, the present invention achieves many advantageous effects, including the following:

- 15 (1) Since vaporizers of air-heated type are employed, no such heat source as electricity, hot water, or steam is necessary. Consequently, there is no danger of ignition, explosion, or fire hazard, and the vaporizers operate safely at low running cost.
- 20 With no need of large power source such as a boiler or liquid-feed pump, the plant is simple in construction and equipment. The construction cost is accordingly low and the plant is easy to maintain and control thanks to the freedom from mechanical trouble and practically no
25 need of maintenance. Elimination of preheating or other

preparatory step quickens the start of operation and reduces calorific value variation.

(2) The operation is easy and lends itself readily to automated, unmanned operation. The operation
5 personnel may be decreased to a minimum.

(3) The plant is non-polluting because it does not produce noise, vibration, waste water or gas, or other public nuisances.

(4) With 100% gasification efficiency, the
10 resulting gas is free from carbon monoxide and harmless to the human being.

(5) The gas holder capacity can be minimized and the construction cost saved accordingly.

(6) Because the gas distribution piping
15 efficiency is markedly increased (by a factor of 2 to 3), existing piping systems may be utilized.

(7) The plant is not only suitable, needless to say, for minor gas utilities but is also suited for larger scale production. It can be most advantageously
20 made small and compact enough for industrial and domestic uses.

(8) Where localized satellite supply becomes necessary by reason of inadequate distribution piping system at the time of changeover from synthetic to
25 natural gas, the mechanical and compact plant of the invention is very advantageously used.

CLAIMS:

1. A plant for the production of propane-air gas characterized by a storage tank for storing liquified propane gas, an air-heated type vaporizer
5 for vaporizing the liquified propane gas from the storage tank, an air mixer for mixing and diluting the propane gas vaporized by the air-heated type vaporizer with air, and calorific-value-adjusting means having a calorimeter and a mixing-air flow regulator, said calorific-
10 value-adjusting means recovering part of the propane-air gas emerging from the air mixer through a line connecting the calorific-value-adjusting means with the air mixer, and determining the calorific value of the recovered propane-air gas by means of said calorimeter,
15 the determined value being used in the manual or automatic control of the quantity of air to be admitted to the air mixer by means of said mixing-air flow regulator.

2. A plant according to claim 1, wherein the line for recovering part of the propane-air gas emerging from
20 said air mixer is of double-pipe structure consisting of a small-diameter inner pipe and a large-diameter outer pipe surrounding and protecting the inner one.

3. A plant for the production of propane-air gas characterized by a storage tank for storing



liquified propane gas, an air-heated type vaporizer for vaporizing the liquified propane gas from the storage tank, an air mixer for mixing and diluting the propane gas vaporized by the air-heated type vaporizer with
5 air, a gas holder for storing the propane-air gas emerging from the air mixer, an air mixer control means for controlling the operation of the air mixer according to the gas quantity inside the gas holder, and calorific-value adjusting means for recovering part of the propane-
10 air gas emerging from the air mixer, and determining the calorific value thereof, the determined value being used in the manual or automatic control of the quantity of air to be admitted to the air mixer.

4. A plant according to claim 3, wherein there is a plurality of air mixers, and said air mixer control means comprises a gas volume detector attached to said gas holder, a line-switching controller for actuating the control valve of a selected air mixer in response to the signal from the gas volume detector,
20 a main regulator for regulating the injection quantity of gasified propane gas introduced into the air mixer, and an operating air-line for actuating the main regulator of said air mixer upon opening of the control valve.

25 5. A plant according to claim 4, wherein



said calorific-value-adjusting means includes a line for recovering part of the propane-air gas emerging from said air mixer, which together with said operating-air line for actuating said air mixer are of double-
5 pipe structure, each consisting of a small-diameter inner pipe and a large-diameter outer pipe surrounding and protecting the inner one.

6. A plant for the production of propane-air gas substantially as hereinbefore described with
10 reference to, and as shown in, the accompanying drawings.
