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Application of Reinforced Composite Piping (RCP) Technology to Liquefied Petroleum Gas Distribution

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Abstract: The age of natural gas and its derivatives like Liquefied Petroleum Gas (LPG) has finally arrived. All vital signs point to its significant increasing role in the total energy picture around the world and it currently applies for one quarter of the world energy supply. Nigeria has abundant gas resources but its effective distribution to meet domestic and industrial needs is a problem the industry must solve. Gas distribution to various homes is operational in different parts of the world but very limited in Nigeria. Currently Liquefied Petroleum Gas (LPG) is distributed using bottles. The problems of safety associated with the bottled gas and its transportation can be avoided by the use of pipelines. The need therefore arises to design gas pipelines with appropriate and cost-effective materials to supply the homes. Pipelines ensure uninterrupted supply of gas to homes for use. This research evaluates the application of Reinforced Composite Piping (RCP) technology in Nigeria and its economic implication. This technology is suited to replace the traditional metallic structures and plastic pipes in the industry by filling critical areas for durable, cost-effective piping systems, excellent corrosion resistance and maintenance free performance. The capacity of RCP pipes to resist fatigue and provide design/fabrication flexibility makes it a suitable technology for effective Liquefied Petroleum Gas (LPG) distribution.

Key words: Liquefied, gas, pipelines, reinforced composite, corrosion, distribution

INTRODUCTION

The age of natural gas and its derivatives like Liquefied Petroleum Gas (LPG) has finally arrived. All vital signs point to its significant increasing role in the total energy picture around the world and currently apply for one quarter of the world energy supply (Ward, 2002). While gas sources are common its distribution vis a vis market location is quite often at great variance. The population of Nigeria is estimated to be one hundred and twenty million and with growing industrial potentials. If this population could put Liquefied Petroleum Gas (LPG) to use in the individual homes through gas distribution it would have been beneficial but the reverse is the case.

It is however, necessary to create awareness that the time to use Liquefied Petroleum Gas (LPG) in Nigerian homes through pipes has come. It is highly commendable to see the efforts being made by the Nigerian government and oil companies in carrying out projects tailored toward proper utilization of Liquefied Petroleum Gas (LPG). This awareness is paramount so that this operational concept in some other parts of the world will not be a mirage in Nigeria.

Liquefied Petroleum Gas (LPG) is one of the safest and cleanest energy sources available. The aim of gas distribution is to provide safe, reliable service at the lowest possible price. Pipeline transport is the most efficient, effective and safest means of moving large volumes of Liquefied Petroleum Gas (LPG) from the point of production to the consumer (Hale, 1975). Nigeria must therefore, confront the salient issues pertaining to Liquefied Petroleum Gas (LPG) pipeline transport vis a vis gathering, transmission and distribution networks.

It is the safest, most economical and reliable method for moving natural gas from the field to the end user. Thus in order for natural gas and its derivatives to be utilized internally to meet the Nigerian energy needs, the effort to create this awareness becomes inevitable.

Gas distribution to various homes through pipelines is operational in different parts of the world but very limited in Nigeria. Currently Liquefied Petroleum Gas (LPG) is distributed using bottles. The problems of safety associated with the bottled gas and its transportation can be avoided by the use of pipelines. The need therefore arises to design gas pipelines with appropriate materials to supply the homes. Pipelines ensure uninterrupted supply of gas to homes for use. This project evaluates the application of Reinforced Composite Piping (RCP) technology in Nigeria and its economic implication.

The objectives of this study include: Create an avenue for uninterrupted supply of Liquefied Petroleum Gas (LPG) to the homes through effective gas piping

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network, encourage the industry on the need to make composite piping an alternative to metallic pipe using Reinforced Composite Piping (RCP) technology and show that gas distribution is a safe and lucrative business. The scope of work includes:

- Analysis of existing gas distribution technologies
- Analysis of Reinforced Composite Piping (RCP) technology
- Analytical comparisons of reinforced composite pipe and steel pipe

This research is the theoretical analysis of the comparison of two methods of gas distribution. It is not a laboratory analyses project based on a higher and advanced state of the art experimental facilities and equipment that are beyond my reach. This research is limited to analyzing Reinforced Composite Piping (RCP) technology to pipe Liquefied Petroleum Gas (LPG) in Nigeria. This is a new concept in the gas industry and will require professional application to discover areas of improvement.

This research work will encourage local and international businessmen to invest in gas distribution technology. It will bring about regulated use of gas in the homes through pipelines using Reinforced Composite Piping (RCP) Technology. The benefits of the technology include stability, lower weight, durability, enhanced corrosion resistance and low economic and life cycle cost.

Liquefied Petroleum Gas (LPG): Liquefied Petroleum Gas (LPG) is a mixture of petroleum hydrocarbons consisting mainly of propane and butane (Whinery, 1958). The technical term is badly chosen because any petroleum gas can be liquefied given the right conditions just as any of the lighted petroleum hydrocarbons can be vaporized and as Liquefied Petroleum Gas (LPG) is not always handled or used as a gas one ends up with such semantic oddities such as liquid phase Liquefied Petroleum Gas (LPG) (LPLPG or LPPG) and vaporized Liquefied Petroleum Gas (LPG) (Campbell, 1974).

The chief attraction of Liquefied Petroleum Gas (LPG) is associated with its ambiguous characteristics. Being a very light hydrocarbon it is relatively easily purified and separated from both heavier and lighter hydrocarbons and from adventitious impurities. It is therefore, one of the cleanest fuel available to domestic, commercial and industrial users and competes effectively for markets with naphtha and kerosene and even when vaporized, it has the same degree of easy control, turn down and combustion efficiency.

Liquefied Petroleum Gas (LPG) can be transported in road and rail tankers and moved in small diameter pipelines, storage can be at the point of production at a secondary re-distribution centre and on consumer premises (Campbell, 1974). Clearly in certain circumstances this must be considered an advantage compared with other gaseous fuels such as natural gas which are difficult to liquefy and cannot be stored by the user other than in the gaseous state.

The principal sources of Liquefied Petroleum Gas (LPG) are oil or gas fields and petroleum refineries. Natural gas is rarely produced from the subsoil in a completely dry condition i.e., containing practically no hydrocarbons heavier than ethane in most fields, substantial quantities of liquids are associated with the gas and have to be separated before the gas can be compressed and piped to centers of consumption (Reid and Sherwood, 1958).

The other source of Liquefied Petroleum Gas (LPG) is the fractionation of crude oil and the further processing of petroleum distillates. Residual Liquefied Petroleum Gas (LPG) in the crude oil is separated during the primary fractionation of oil refinery feedstock together with propane/butane resulting from other forms of refinery processing such as catalytic refining, hydrogenation catalytic cracking and thermal cracking or coking, the refinery gases are collected into a common stream, fractionated and purified before they are compressed or refrigerated for dispatch and sale.

Distribution of Liquefied Petroleum Gas (LPG): The delivery of Liquefied Petroleum Gas (LPG) to its point of end use by a distributor is much like its transportation. However, distribution involves moving smaller volumes of gas at much lower pressures over shorter distances to a great number of individual users. Smaller diameter pipe is used to transport Liquefied Petroleum Gas (LPG) form the city gate to individual consumers. The Liquefied Petroleum Gas (LPG) is periodically compressed to ensure pipeline flow although, local compressor stations are typically much smaller than those used for inter state transportation. Because of the smaller volumes of Liquefied Petroleum Gas (LPG) to be moved as well as the small diameter pipe that is used, the pressure required to move Liquefied Petroleum Gas (LPG) through the distribution network is much lower than that found in the transmission pipelines. While Liquefied Petroleum Gas (LPG) traveling through interstate pipelines may be compressed to as much as 1300 pounds per square inch (psi), Liquefied Petroleum Gas (LPG) traveling trough the distribution network requires as little as 3 pounds per square inch (psi) of pressurization.

Traditionally, rigid steel pipe was used to construct distribution networks. However, new technology is allowing the use of flexible plastic in place of rigid steel pipe. These new types of tubing allow cost reduction and installation flexibility for both local distribution companies and Liquefied Petroleum Gas (LPG) consumers.

Gas flowing from higher to lower pressures is the fundamental principle of the Liquefied Petroleum Gas (LPG) delivery system. The amount of pressure in a pipeline is measured in pounds per square inch (Nolte, 1979).

Gate stations: When the Liquefied Petroleum Gas (LPG) in a transmission pipeline reaches a local gas utility, it normally passes through a gate station. Utilities frequently have gate stations receiving gas at many different locations and from several different pipelines. Gate stations serve three purposes. First, they reduce the pressure in the line from transmission levels (200-1500 pounds) to distribution levels which range from ¼ pound to 200 pounds. Then an odorant, the distinctive sour scent associated with Liquefied Petroleum Gas (LPG) is added so that consumers can smell even small quantities of gas. Finally, the gate station measures the flow rate of the gas to determine the amount being received by the utility.

Transmission system: From the gathering system, the Liquefied Petroleum Gas (LPG) moves into the transmission system. These large transmission lines for Liquefied Petroleum Gas (LPG) can be compared to the intestate highway system for cars. They move large amounts of Liquefied Petroleum Gas (LPG) thousands of miles from the producing regions to Local Distribution Companies (LDCs.). The pressure of gas in each section of line typically ranges from 200-1,500 pounds per square inch, depending on the type of area in which the pipeline is operating. As a safety measure, pipelines are designed and constructed to handle much more pressure than is ever actually reached in the system. For example, pipelines in more populated areas operate at less than one-half of their design pressure level.

Compressor stations: Compressor stations are located approximately every 50-60 miles along each pipeline to boost the pressure that is lost through the friction of the Liquefied Petroleum Gas (LPG) moving through the pipe. Many compressor stations are completely automated so the equipment can be started or stopped from a pipeline's central control room. The control center also can remotely operate shut-off valves along the transmission system. The operators of the system keep detailed operating data on each compressor station and continuously adjust the mix of engines that are running to maximize efficiency and safety.

Linepack: A 50 mile section of 42 inch transmission line operating at about 1,000 pounds of pressure contains about 200 million cubic feet of gas enough to power a kitchen range for >2,000 years. The amount of gas in the pipe is called the LINEPACK.

By raising and lowering the pressure on any pipeline segment, a pipeline company can use the segment to store gas during periods when there is less demand at the end of the pipeline. Using LINEPACK in this way allows pipeline operators to handle hourly fluctuations in demand very efficiently.

The distribution system: From the gate station, natural gas moves into distribution lines or mains that range from 2 inches to >24 inches in diameter. Within each distribution system, there are sections that operate at different pressures with regulators controlling the pressure. Some regulators are remotely controlled by the utility to change pressures in parts of the system to optimize efficiency.

Moving Liquefied Petroleum Gas (LPG) into the home: Liquefied Petroleum Gas (LPG) runs from the main into a home or business in what's called a service line. Today this line is likely to be a small-diameter plastic line of an inch or less in diameter, with gas flowing at a pressure range of over 60 pounds to as low as ¼ pound. When the gas passes through a customer's gas meter, it becomes the property of the customer. Once inside the home, gas travels to equipment and appliances through piping installed by the homebuilder and owned by the customer who is responsible for its upkeep.

When the gas reaches a customer's meter, it passes through another regulator to reduce its pressure to under ¼ pound if this is necessary (Some service lines carry gas that is already at very low pressure). This is the normal pressure for Liquefied Petroleum Gas (LPG) within a household piping system and is less than the pressure created by a child blowing bubbles through a straw in a glass of milk. When a gas furnace or stove is turned on the gas pressure is slightly higher than the air pressure so the gas flows out of the burner and ignites in its familiar clean blue flame.

Background of piping materials

Plastics: Plastics are materials made up of large, organic (carbon-containing) molecules that can be formed into a variety of products. The molecules that compose plastics are long carbon chains that give plastics many of their useful properties. Like metals, plastics come in a variety of grades. Also like metals, some plastics can be alloyed or blended to combine the advantages possessed by several different plastics. Plastics are used extensively by many key industries including the automobile, aerospace, construction, packaging and electrical industries.

Plastics possess a wide variety of useful properties and are relatively inexpensive to produce. They are lighter than many materials of comparable strength and unlike metals and wood, plastics do not rust or rot. Most plastics can be produced in any color. Plastics have a lower density than that of metals, so plastics are lighter. Most plastics vary in density from 0.9-2.2 g cm^{-3}, compared to steel's density of 7.85 g cm^{-3}. Plastic can also be reinforced with glass and other fibers to form incredibly strong materials. All plastics can be divided into two groups: thermoplastics and thermosetting plastics. These terms refer to the different ways these types of plastics respond to heat. Thermoplastics can be repeatedly softened by heating and hardened by cooling. Thermosetting plastics on the other hand, harden permanently after being heated once.

Thermosetting plastics consist of chain molecules that chemically bond or cross-link with each other when heated. When thermosetting plastics cross-link, the molecules create a permanent, three-dimensional network that can be considered one giant molecule. Thermosetting plastics are often used to make heat-resistant products because these plastics can be heated to temperatures of 260°C (500°F) without melting.

Pipes: A pipe is a hollow structure usually cylindrical for conducting material. It is used primarily to convey liquids, gases or solids suspended in a liquid for example, slurry. It is also used as a conduit for electric wires (Michalski, 2003). Until cast iron became relatively cheap in the 18th century, most pipes were made of bored stone or wood, clay, lead and occasionally copper or bronze. Modern materials include cast iron, wrought iron, steel, copper, brass, lead, concrete, wood, glass and plastic.

According to the Columbia Encyclopedia, steel pipe in troduced in the early century is widely used for conducting substances at extremely high pressures and temperatures. Cast-iron pipes which came into common use in the 1840s, resist corrosion better than steel pipes and are therefore frequently used as underground pipes. A pipeline carries water, gas, petroleum and many other fluids over long distances. In laying an oil pipeline, 40 feet (12 m) sections of seamless steel pipe re electrically welded together while held over a trench. Before being lowered into place, the pipe is coated with paint and wrapped with a substance composed of treated asbestos felt and fiberglass. Pumping stations located 50-75 miles (80-120 km) apart boost the dwindling pressure back up to as much as 1500 lb $inch^{-2}$. The piping must be kept clean, either by applying a negative electrical charge to the pipe or by the regular use of a pig or scrubbing ball in serted at one and carried along by the flow.

Analysis of existing gas distribution technologies: Laney (2002) review that composites and plastics have been used for flow lines, gathering lines and distribution lines but they are yet to be accepted in high-pressure Liquefied Petroleum Gas (LPG) transmission systems. They stated that the results of their investigation indicate there are a number of barriers that need to be overcome to make large diameter composite pipe a viable alternative for high-pressure Liquefied Petroleum Gas (LPG) transportation in the future. They however concluded that the goal of any future research should not be to make composites equal to steel pipe but to make composites the pipe material of choice for high-pressure large diameter oil and Liquefied Petroleum Gas (LPG) transmission pipelines.

Glass Reinforced Epoxy (GRE) pipe provides the best all-round chemical resistance and they also noted that other types of resin may also be used. These include:

- Isophthalic polyester for general purpose products
- Vinyl ester which often shows corrosion resistance approaching that of epoxy
- Phenolic include phenolic/siloxane alloy, PSX, recently developed for fire-critical applications

Ameron BV has consider Glass Reinforced Epoxy (GRE) as the most important material and it has been used onshore for both low and high pressure applications with a wide variety of fluids in cluding hydrocarbons.

The chemical resistance of GRE and the maximum use temperature in a particular fluid depends on the type of resin and hardener used. GRE tubes are largely immune to the effects of hydrogen sulphide and carbon dioxide as well as the main organic components of crude oil.

Eckold in his study presentation stated that composites are not new materials in terms of oil and gas recovery applications and there are a number of examples where they have performed well. He however, stressed that further development programs should be focused on lightweight materials that will replace steel pipe for drill pipe.

Table 1: Comparative specific properties of composite, steel and aluminum

Properties	Specific gravity	Specific strength Mpa (Air)	Specific modulus Mpa (Air)	Specific strength (Mud SC 1.2)	Specific modulus Gpa (Mud SG 1.2)
GFRP (High modulus)	1.6	1000-1100	150-180	4000-4400	600-1200
(High strength)	1.5	1300-2000	100-120	5200-8000	400-480
Glass Reinforced pipe (GRE)	2.0	500	21	1250	53
Mild steel	7.8	130	26	150	30
Aluminum	2.8	170	27	300	47

Eckold *et al.* (1991) 1 Mpa = 0.147 Psia

Composites are combined from engineering materials that are prime candidates for a possible alternative to corrosion prone steel. They show in Table 1, the properties of composite materials compared to steel and aluminum showing that the values for composites are much higher than their metal equivalents.

An alternative material which promises to overcome the limitations of metallic materials for the construction of coiled tubing can be found in composites. Fibrous composite materials can be tailored to exhibit unique anisotropic characteristics to optimally address burst and collapse pressures as well as tensile and compression loads (Sas-Jaworsky and Williams, 1993).

MATERIALS AND METHODS

Analysis of Reinforced Composite Piping (RCP) Technology: Reinforced Composite Piping (RCP) Technology is a new method of making pipelines that can transport gas and its derivatives. It involves the combination of fiber and epoxy reins to form a matrix or composite. The composite is reinforced with a particular material that will enhance a particular quality of a pipeline:

RCP = Reinforcement+Fibre+Epoxy resins

The fiber is usually glass while the reinforcement includes any of these:

- Carbon fibers to reduce the effect of environmental interaction, moisture, atmosphere, solvents, bases and weak acids on pipes
- Cellulose fibers in a composite to produce a material with dramatically increased tensile properties. Both modulus and strength of pipe increases
- Aramid fibers like Kevlar increase resistance to solvents and chemicals

This combination produces a pipe that is safe and cheap to transport Liquefied Petroleum Gas (LPG). Filament winding requires continuous fiber reinforcement and a resin system to bind things together. There are many types of materials that can be used in this process. The choice of materials for a particular product depends more upon the economics, the environmental resistance, corrosion resistance, the weight limitations and the strength performance requirements all play an important in this decision (Table 2).

Table 2: Property comparison: filament wound composite and others

Material	Density (g/cc)	Tensile strength (Mpa)	Tensile modulus (Mpa)	Specific tensile strength (10^3m)
Filament wound composite	1.99	1034	31.02	52.96
Aluminum 7075-T6	2.76	565	71.01	20.87
Stainless steel-301	8.02	1275	199.94	16.20
Titanium alloy (Ti-13 V-12, Cr-3 Al)	4.56	1275	110.30	28.50

C_K composites, Mount Pleasant, PA

Table 3: Filament wound products: applications Vs resin systems used

Industry	Typical application	Typical resin system
Corrosion	Underground storage tanks	
	Aboveground storage tanks	
	Piping systems	Polyester (Ortho and
	Stack liners	Iso-phthalic),vinyl ester,
	Ducting systems	epoxy, phenolic
Oilfield	Piping systems	Epoxy, phenolic
	Drive shafts	
	Tubular systems	
	Piping systems	
Marine	Drive shafts	Epoxy
	Mast and boom structures	

Resins: Resin systems come in a variety of chemical families, each designed to provide certain structural performance, cost and/or environmental resistance. Fibers can be either thermoset or thermoplastic.

A thermoplastic polymer resin is distinguished by their ability to reshape upon the addition of heat. Composites differ from traditional materials in that composite parts comprise two distinctly different components-fibers and a matrix material (most often a polymer resin) that when combined, remain discrete but function interactively to make a new material whose properties cannot be predicted by simply summing the properties of its components. In fact, one of the major advantages of the fiber/resin combination is its complementary nature. Thin glass fibers for example, exhibit relatively high tensile strength but are susceptible to damage (Table 3).

By contrast, most polymer resins are weak in tensile strength but are extremely tough and malleable. When combined the fiber and resin each counteract the other's weakness, producing a material far more useful than either of its individual components.

In fibre-reinforced composites, fibres are the principal load carrying members while the surrounding matrix keeps them in the desired location and orientation. Matrix also acts as a load transfer medium between the fibres and protects them from environmental damages due to elevated temperatures, humidity and corrosion. This general definition covers the various types of pipe currently used in oil and gas transmission which includes metal, plastic and thermosetting resin pipe as well as various combinations of these three types.

A more precise definition for thermosetting composites would be a combination of a reinforcement fiber in a thermosetting polymer resin matrix where the reinforcement has an aspect ratio that enables the transfer of loads between fibers and the fibers are chemically bonded to the resin matrix. These new breeds of nonmetallic materials developed many years ago-Fiber Reinforced Polymer (FRP) composites-believed to have delivered the stealth aircraft can also eliminate corrosion from oil and gas pipelines.

These materials are applicable to new pipelines, maintenance and rehabilitation of existing piping system because of its unique properties such as lighter weight, ability to withstand high internal pressures, excellent corrosion resistance, torsional stiffness and impact resistance, better dimensional stability over temperature fluctuations due to low coefficient of thermal expansion, lower life cycle cost and smooth surfaces.

A thermoplastic polymer resin distinguishes by their ability to be reshaped upon the addition of heat (above the glass transition temperature of the amorphous phase or the melting temperature of the crystalline phase). Thermosetting polymers, on the other hand, undergo chemical reactions during curing which crosslink the polymer molecules and become permanently hard. Thermosetting polymer resins have greater abrasion resistance and dimensional stability over that of thermoplastic polymers which typically have better flexural and influence properties.

Their advantages include a wide range of formulations, exothermic reactions during the curing (liquid-to-solid) stage, shrinkage, creep, resistance to high temperatures, good solvent resistance, corrosion resistance (a definite advantage in a offshore environment) and good mechanical and electrical properties.

Disadvantages stemming from the use of thermosets include brittleness, lengthy cure cycles and inability to repair and/or recycle damaged or scrapped parts. Compared with thermosets, composites fabricated from thermoplastic materials typically have a longer shelf life, higher strain to failure are faster to consolidate and retain the ability to be repaired, reshaped and reused as need arises.

Thermoplastic melts as opposed to thermosetting resins have a substantially higher viscosity. Additional problems caused by high matrix viscosity during consolidation include de-alignment of reinforcing fibers during consolidation as well as the introduction of voids within the final composite product. All of these problems can be address by appropriate design regarding the fiber-matrix interface as well as optimization of composite fabrication procedures. Composites prepared with satisfactory matrix dispersion within the fiber tows as well as reasonable fiber-matrix adhesive interaction typically results in composites with good mechanical properties.

RESULTS AND DISCUSSION

Analytical comparisons of Reinforced Composite Pipe (RCP) and steel pipe: High alloy steel pipes have good corrosion resistance characteristic but the prospecting high cost because of maintenance, monitoring in spection, corrosion in hibitor and staff costs methods of corrosion control has necessitated the use of reinforced composite piping.

Advantages of composite piping to steel piping in this work are inherent corrosion resistance abrasion resistance, operational costs, service life and flexural strength etc.

Chemical resistance comparison: Chemical resistance is the factor most limiting steel's use since unprotected steel will oxidize (rust). The oxidize coating generally has a smaller volume than the base metal and will crack, leaving the base metal unprotected. Hence, there are various protective coatings but their effectiveness is limited by durability and can be damaged by shipping and handling in stallation bedding and backfill placement as well as internal abrasions from live loads. Composite are highly resistant to many corrosive chemicals and compounds in cluding Hydrogen Sulphide (H_2S). Some pipelines operators implored composite materials to wrap steel pipe to improve the structural properties while at the same time adding external corrosion resistance that the steel previously lacked. In fact when strength to weight ratios are examined composites can be much stronger than steel.

Abrasion resistance comparison: Abrasion resistance is a material's ability to withstand mechanical erosion. Pipes used in the oil and gas industry require significant abrasion resistance since, grit and suspended solids continuously affect the pipe wall. As flow velocity increases, so does abrasion. Composite pipe is highly resistant to abrasion. This is because its molecular composition creates a trampoline response when impacted by tumbling aggregate (such as grit and solids).

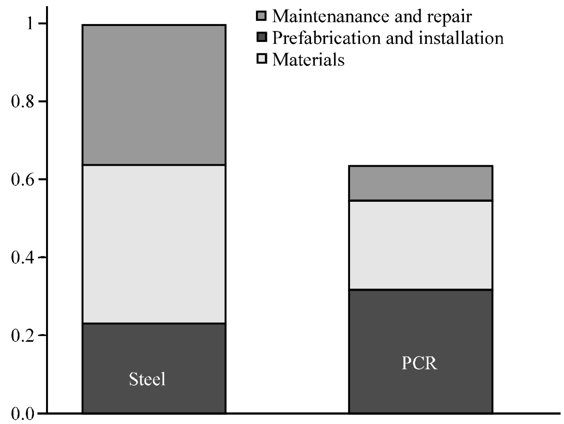

Fig. 1: Total cost of traditional steel piping compared to reinforced composite pipes (Ameron®, Fiberglass Pipe Group, Burkburnett Tx

Steel has better abrasion resistance but more susceptible abrasion than composite. However reinforcement in reinforced composite pipe fabrication to increase abrasion resistance though the smooth-wall of composite provides the most effective abrasion.

Steel welding comparison: A pipe made of reinforced composite pipe materials can be constructed and put in service in a relatively short time and at a competitive cost. Its consideration bring hope of avoiding introduction of welding associated risk eliminates cost and service outages associated with conventional repairs compared to steel piping which require pipeline shutdown prior to welding.

Flexural strenght comparison: Composites are significantly more flexible than steel while permitting efficient continuous production methods that can facilitate transportation and field installation. Although, it's more expensive than steel drill pipe, the composite pipe has a big advantage. It can remain bent for extended periods while rotating without suffering fatigue making it particularly well suited for short radius horizontal applications.

Operational cost comparison: Composite piping, being just a quarter to an eighth the weight of steel pipes is easy to install without the need of heavy installation equipment welding or cathodic protection compared to steel pipes that require a huge expense. However, composite pipe manufacture costs exceed those of conventional steel piping systems in which the total life cycle costs of composite pipes compare favorably when other operational costs such as installation and maintenance are considered.

Generally, the huge cost savings for any oil production facility is the prevention of corrosion failure which contributes to failures I the down hole tubing, flow lines, gathering lines and distribution lines. A comparison of costs as shown in Fig. 1 clearly shows the savings during the service life of the piping system.

CONCLUSION

Gas distribution to various homes is operational in different parts of the world but very limited in Nigeria. Currently Liquefied Petroleum Gas (LPG) is distributed using bottles. The problems of safety associated with the bottled gas and its transportation can be avoided by the use of pipelines. The need therefore arises to design gas pipelines with appropriate and cost-effective materials to supply the homes. Pipelines ensure uninterrupted supply of gas to homes for use.

This project has presented Reinforced Composite Piping (RCP) Technology as a superior alternative to using traditional materials like steel for making pipelines. RCP replaces the traditional metallic structures and plastic pipes in the industry by filling critical areas for durable, cost-effective piping systems, excellent corrosion resistance and maintenance free performance.

Analysis of the cost of material in Fig. 1 shows that pipes using RCP Technology has a higher cost for materials but much cheaper to fabricate in stall and maintain when compared to steel pipes. The petrochemical oil and gas industry in Nigeria should embrace reinforced composite piping technology as a choice gas distribution technology.

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