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Study of Multilayered Composite Pipe subjected with Metal Interlayer

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Abstract - *The influence of an internal pressure on the integrity of multilayered composite pipe is studied in this paper. The multilayer pipe is modeled as a particular case of bi-material body consisting of one main metal layer and two protective layers. The multilayered composite pipelines have advantages of both metal and plastic, such as good strength of metal and light weight of plastic are observed. Metal pipes are destroyed by corrosion failure and plastic pipes are destroyed by brittle-like failure. To prevent this type of pipe damage use of alternative multilayered composite pipe is suggested.*

Key Words: **Multilayered composite pipe, Internal pressure, bi-material interface, Protective layers, PE-Polyethylene pipe.**

1. INTRODUCTION

Plastic (polyethylene) pipes are nowadays frequently used for the transportation of liquids and gases from one place to another. A diverse range of plastic pipes has been developed to meet the demands of end users. The prevention of their failure is of great practical significance. To guarantee the longer lifetime of pipe systems, composite pipes consisting of many layers are employed in practice. These are of cardinal importance, especially in connection with trenchless installation techniques [14]. Homogeneous (one-layer) polyethylene pipes can be destroyed by cracks initiated at the surface and propagating through the pipe wall. This type of pipe failure is frequent. In many cases, plastic pipes are then cracked in a brittle-like manner. To prevent this type of pipe damage multi-layered composite pipes are used. The development of multilayered composite pipes is connected with new technologies which have not yet been able to be employed in laying new tubes and sanitation. Multi-layered composite pipes can consist of many layers, with different functions and manufacturing facilities must be designed specifically for the various pipe structures. Due to its practical importance the multi-layered composite pipes are studied from a different point of view [1].

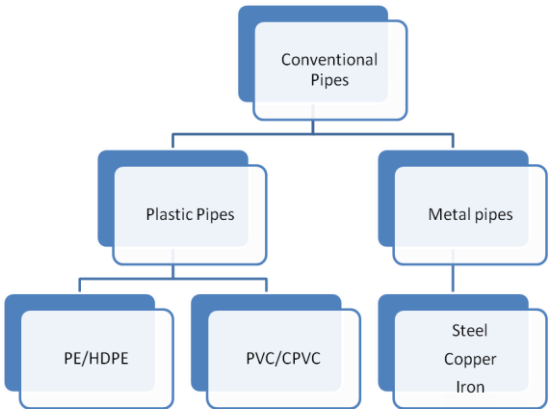

Chart -1: Types of the conventional pipes used for transportation of liquids and gases for the low pressure system.

1.1 Advantages of multilayered composite pipe

The important mechanical properties of a composite pipe are strength, stiffness and service life, which make it imperative to determine leakage integrity and reliability of a piping system high. Multilayered composite pipes have many potential advantages over pipes made from conventional materials, such as specific stiffness and strength, good corrosion resistance, light weight and good thermal properties. Composites offer many cost advantages over metals due to a considerably higher strength to weight ratio. For example, an increase in the ease of handling decreases the amount of manpower and size of equipment needed for construction and installation [6].

1.2 Applications of multilayered composite pipe

Multilayered composite pipes are mainly used for water and gas supply [14]. It is also used for various applications such as compressed air systems, natural gas distribution, submersible pump piping, jet pump piping, fuel oil lines, vacuum systems, food/chemical processing, refrigerant systems, air conditioning, solar heating, under floor heating, radiator central heating system etc.

2. Multilayered composite pipe system

Basically, multilayered composite pipes are composed of one main layer (the functional pipe) and a few protective layers

as shown in fig.1. The single layers are normally tightly bonded to each other. In the case of poor handling and/or faulty installation of pipes, small cracks or flaws can be created at the surfaces of a pipe and propagated through the pipe body. Other possible causes of crack initiation are connected with stress enhancers and stress concentration. The essential function of the protective layers is to prevent damage to the main pipe caused by surface cracks [14]. To achieve this, the material for protective layers should be chosen properly; in particular, it has to have greater resistance against surface scratching. Polymeric materials such as PE-polyethylene, PP-polypropylene, PVC-polyvinylchloride shows such property [1].

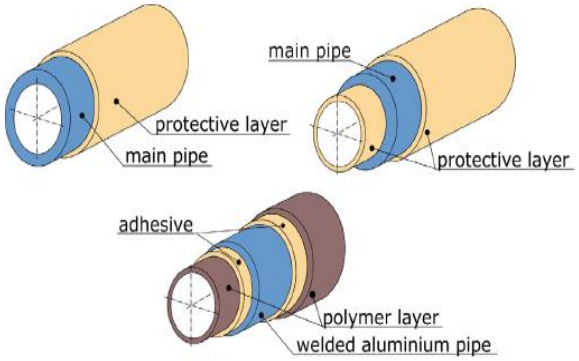

Fig -1: Multilayered composite pipe system

2.1 Relevance

Composite systems are widely used in piping industries. The composite pipelines have the advantages of both metal and plastic, such as good mechanical properties of metal and good chemical properties of plastic. Therefore the composite pipelines are widely used in the areas such as water supply, heat supply, chemical industries, petroleum and natural gas transportation etc.

The properties of composites make them ideal in the oxidizing or reducing atmospheres generally found in these industries. Under the most corrosive environment, the life of metal pipe can only be measured in a few years (approximately 10 years), while the life of multilayered composite pipe is about 50 years. Homogeneous (one layer) plastic pipes can be destroyed by brittle fracture. A more effective solution is the use of multilayered composite pipe. Composites also have higher strength to weight ratios compared to traditional engineering materials. Their low weight can help reduce installation and repair costs.

2.2 Research issues

It is seen that majority of the research work is reported on reinforced plastic pipes and multilayered filament wound composite pipes but the less work is reported on multilayered composite pipes subjected with metal interlayer.

Study revels following issues.

1) Few studies were focused on the strength to weight ratio of conventional pipes and multilayered composite pipe for applications demanding low weight and high strength for low pressure systems.

2) There are fewer studies on the multilayered composite pipes for different profiles and/or orientations (rectangular/circular) for the application of weight reduction.

3) It is found that few researchers have focused on the elastic mismatch of the protective layer and the main layer of multilayered composite pipes.

4) There are fewer studies on the probability of failure of multilayered composite pipes by fracture mechanics approach and by stress concentration.

5) The considerable work has been reported on multilayered composite pipe for stress analysis using analytical methods and its failure due to fracture mechanics approach. However, very little work has been reported on the study of multilayered composite pipe under internal pressure by changing the materials of the layers and analysis of it by using finite element methodology.

3. CONCLUSIONS

The conventional pipe for carrying fluids at low pressure is typically made of metal or plastic. The weight of the metal pipe for long and complex piping system becomes a matter of concern and the plastic pipes can be destroyed by brittle fracture. So the strength to weight ratio is not favorable for applications demanding low weight in case of metal pipe and for applications demanding high strength for low pressure systems in case of plastic pipe.

Multilayered composite pipes have higher strength to weight ratios compared to traditional engineering materials. Their low weight can help reduce installation and repair costs. The composite pipelines have the advantages of both metal and plastic, such as good mechanical properties of metal and good chemical properties of plastic.

A more effective solution for the low pressure gas or liquid pipeline is the use of multilayered composite pipe.

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