A survey of GRP Pipes Defects and Damage Due to Fabrication Processes

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***Abstract*—** Glass Reinforced Plastics, commonly known by various standards, as Fiber Reinforced Plastics (FRP), GRP, Glass Fiber Reinforced Plastic (GFRP), Reinforced Plastic Mortar Pipe (RPMP) or Reinforced Thermo-set Resin Plastic (RTRP) is an amalgamation of resin, glass fiber, manufactured using appropriate additives and treatment methods. It is a composite engineering material uniquely capable of meeting a wide variety of specific processes and end product requirements of various applications of fluid transport requirements.

GRP piping system is often utilized in almost all applications to withstand aggressive service, ambient and environmental conditions. It has been successfully used in various piping systems and applications over the entire world. GRP piping industry in Libya has just started (i.e. since 2009), so such manufacturing plants are facing some difficulties during commissioning and production trails stage. GRP piping industry has wide variations both in designs and manufacturing techniques used.

This paper will focuses and discuss the possible defects associated with the production of GRP pipes, from the point of view of human error, and or lower manufacturing skinless due to new technology introduction in the area. The survey will involve and demonstrate the usage of GRP for various aggressive fluids and its consequences. Finally, concluding remarks concerning defect types, causes, and the prevention of such defects will be presented.

Index Terms - composite materials, Glass fiber reinforced plastics , GRP piping industry.

I. INTRODUCTION

Glass Reinforced Plastics pipes (GRP Pipe), it is a composite engineering material uniquely capable of meeting a wide variety of specific processes and end product requirements of various applications of fluid transport requirements. It has a combinations of properties generally not found in any other traditional or conventional material, these include exceptionally high strength to weight ratio (have low thicknesses and high mechanical properties-with stands high pressures), superior corrosion resistance (no scaling and no buildup), maintenance free, higher hydraulic efficiency (smaller sizes), light weight (lower transportation and installation costs), higher resistance to surge pressure (more safer under worst conditions due to its low modulus of elasticity), best joining systems, excellent workability and design flexibility's. Thus allowing GRP piping to be used for high pressures and in very tough and rough conditions.

GRP piping system is often utilized in almost all applications to with stand aggressive service, ambient and environmental conditions. It has been successfully used in various piping systems and applications in all of the world.

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FRP piping industry is around 40 to 50 years old and has vide variations both in designs and manufacturing techniques. GRP materials have been used with increasing frequency within the petroleum industry during the last 10 years, and are particularly suited for offshore applications. Compared to many metallic materials, GRP provides low costs, and faster, easier installation. The lack of commonly accepted inspection practices and defect acceptance criteria causes most GRP users some uncertainty, which typically results in additional costs associated with overly conservative or non conservative responses.

If the machine setup is according to the specifications in setup sheet and raw materials are tested and approved, there are normally no problems with defects on pipes. But sometimes process variables changes during the production and may cause defects on pipes. Defects can occur in either the GRP material or in the mechanical and adhesive bonded joints that make up a piping system.

This paper will discuss the possible defects can occur in either the GRP material or in the mechanical and adhesive bonded joints that make up a piping system involved with GRP piping systems. Highlights of the past years of experience of GRP piping in all applications, indicating that how GRP piping is performing in vary harsh and aggressive environments both internally and externally. Also this paper demonstrates the visually identify defects on pipes, how to repair them, and suggestions for corrective actions in order to avoid these defects.

II. GRP PIP MATERIALS

A. Resin Systems

The Manufacturer will use only approved polyester or Vinyl ester resin systems for which he can provide documented performance in this particular application. The data shall have been acquired from a composite material of similar construction and composition as the product proposed for this project.

B. Glass Reinforcements

The reinforcing glass fibers used to manufacture the components shall be of highest quality commercial grade of glass filaments suitably treated with binder and sizing compatible with impregnating resins of ECR type. The glass reinforcement forms are: C-veil, direct roving, and chop roving. Unidirectional (Axial Tape) glass reinforcement may also be used.

C. Fillers

Silica sand or other chemically compatible fillers may be used in the laminate.

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III. GRPPIPES MANUFACTUREAND CONSTRUCTION

The pipes shall be supplied in accordance with diameter and tolerances according to the design specification. They shall be manufactured by controlled, continuous filament winding process with a winding angle of 87° to 89° using the materials described in previous section to result in a corrosion resistant composite structure to meet the operating conditions for the required project for each pipe diameter. The most advanced state-of-the-art process for manufacturing large diameter GRP pipe is the continuously-advancing mandrel process. The winder accommodates a range of diameters from 100mm to 4000mm. The basic winder is composed of a continuous steel band supported by beams which form a cylindrically shaped mandrel. The beams rotate, friction pulls the band around and roller bearings allow the band to move longitudinally so that the entire mandrel continuously moves in a spiral path toward the end of the machine. As the mandrel moves, fine graded filler, glass fibers, resin and surface materials are metered on in precise amounts under the direction of a programmable logic controller (PLC) and computer (PC).

The PLC-PC modules provide integrated process control based on pre-programmed recipes. Only basic pipe data such as diameter, pressure and stiffness class needs to be entered and the computer calculates all the machine settings. Schematic diagram of continues filament winding is shown in Fig.(1). Material consumption as well as pipe thickness is continuously monitored and logged. The logged data is ac-cumulated and reports printed when needed. Stiffening ribs may be used to increase the overall pipe stiffness. They can be of glass fiber filament-wound or glass fiber woven roving construction using similar resin as used in the pipe cylinder.

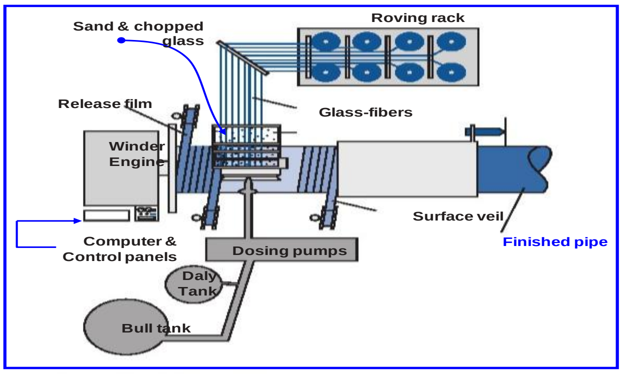


Fig.(1) Schematic Diagram of Continuous Filament winding

1) Visual Defects on GRP Pipe

If the machine setup is according to the specifications in setup sheet and raw materials are tested and approved, there are normally no problems with defects on pipes. But sometimes process variables changes during the production and may cause defects on pipes. Defects can occur in either the GRP material or in the mechanical and adhesive bonded joints that make up a piping system. Pipe defect action sequence with the process or after should be followed as mention in Fig.(2).

In this section will discuss the possible defects associated with the production of GRP pipes, from the point of view of human error, and or lower manufacturing skinless due to new technology introduction in the area. Also in this part will be concerning the defect types, causes, and the prevention of such defects. See as demonstrated in the Table. 1. Pictures and text in this paper will give an excellent presentation about:

1) visually identify defects on pipes
2) how to repair them
3) suggestions for corrective actions in order to avoid these defects.

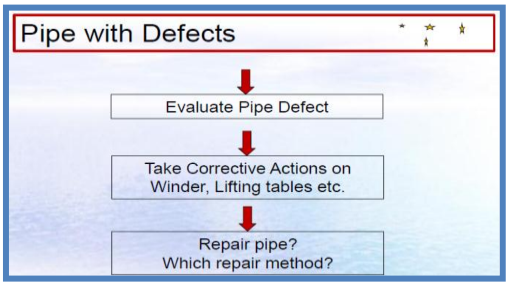
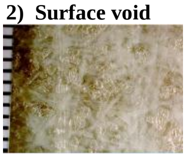


Fig.(2) Sequence of evaluation of the defected GRP pipe

Table.1

VISUAL DEFECT	DEFINITION	WHAT TO DO?	CAUSES / HOW TO PREVENT
1) Craze 	Star shaped figure on inner or outer surface.	All crazes have to be repaired with method no. 1	Sharp impacts or rough transport or handling.
2) Surface void 	Small air pockets or voids beneath the surface mat. Air pockets can be broken with ball pen.	Single void: If >1.5mm deep or >15mm diam., then repair. Group of voids: Only repair if there are more than 4 voids per 0.1m2 and diam <15mm and depth <1.5 mm: Repair method no. 2.	Curing speed is too high (styrene is entrapped in surface).
3)Irregular Thickness & Wavy. 	Spiraling impressions near the liner surface	>3mm deep: Repair pipe. 0-3 mm deep and more than 1/3 of nominal thickness: Repair pipe. Repair method no.	Steel band not properly installed, or too high steel band tension.

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4) Cracks & missing chop 	Lines in circumferential direction	Adjust the material application	Excess resin cured without glass fiber reinforcement, or resin cured at too high temp.
5) Dry & wrinkles 	**Spiraling** impressions near the liner surface with resin **Glass** not impregnated	>3mm deep: Repair pipe 0-3 mm deep and more than1/3 of nom. thickness, then repair with method no. 1.	**Accumulated** - Chop glass falls on laminate during cleaning of chopper etc. - Resin flow is too low or viscosity is too high. **Steel band** not properly installed, or too high steel band tension. Adjust Return head
1)Core delamination 	Separation of layers; longer than 25 mm	Pipe to be repaired, cut if necessary	- Too much sand - Saw impact - Lifting tables
2) Surface pit 	Pit > 1.5mm in diam and 1.5 mm deep.	All pits have to be repaired	Air pockets in inner liner or outer surface
3) Resin rich 	Lines in circumferential direction	Adjust the material application	Excess resin cured without glass fiber reinforcement, or resin cured at too high temp.

V. Conclusions

GRP piping system is often utilized in almost all applications to with stand aggressive service, ambient and environmental conditions. Hence it is an important issue to investigate and assessment of the possible defect and damage that possibly occur to such pipe, especially it has to be controlled from raw materials , during process and after final product of GRP pipe completed. In order to save time and cost in the plant inspection of visual defects and get their causes and propose the way of preventing becomes an essential procedure in the production of GRP pipes. So the main remarks in this paper which gives an excellent presentation about:

- visually identify defects on pipes
- how to repair them
- suggestions for corrective actions in order to avoid these defects.

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25/09/1959. he has awarded the following degrees :Ph.D. Mechanical Engineering, Department of Mechanical & Industrial Engineering, University of Manitoba, Winnipeg, Manitoba, Canada. M. Sc. Mechanical Engineering, Department of Mechanical Engineering, Aerospace Option, McGill University, Montreal, Quebec, Canada. B. Sc. Aeronautical Engineering, Department of Aeronautical Engineering, University of Tripoli, Tripoli, Libya.

Over 25 years of successful professional and academic experience. This experience has taken place in Libya, Canada, and the USA. He spent more than 20 years in teaching and university management at different universities in Canada and Libya. In companies management and business, he has been directly involved in promoting and opening unique business and investment opportunities within Libya. His professional relationships range from academia to governmental agencies to private commercial enterprises.

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Prof. Abdussalam Gashoot, Saleh awarded many awards some of them are: -

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- 1979 Training Course at DeHavilland Aircraft & Air Canada.

Finally, Prof. Abdussalam Gashoot Published papers and research work in the field of aircraft structure, Composite materials, Design, industrial and mechanical vibration in international conferences and journals.