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Practical Insight into the Un-Piggable Problem with Emphasis on Oil and Gas Pipelines

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Abstract: **Pipelines classified as the safest and economical methods used to transport all manner of fluids from one destination to another in all fields start from oil and gas to the food industry. Currently, there are millions Km of pipeline in services in the Oil and Gas industry. Off course these assets need to be integrated to keep a huge amount of investments especially for offshore pipelines when the cost of installation or repair will be multiply by 10.**

Pipelines specially Transmission" are the main 'arteries' of the oil and gas industry; working 24 hours per day, seven days a week, continuously providing our energy needs. They are critically important to most countries' economies.

To achieve pipeline integrity, first clean pipeline is to be maintained through using pipeline pigging procedures. Pigging improves product quality, reduces pumping demand power, restores full flowing capacities, and reduces downtime. In addition, the pigging process is ideally considered non-destructive to the pipe, and therefore pigs are used for all types of pipe construction materials (steel, and epoxy lined).

Through pipeline inspection by using intelligent pigging or what called In line Inspection ILI ,all pipeline condition may be evaluated and assessment without any disturbance or effecting the operation parameters, which lead to the importance of ILI in our new era. Off course to perform ILI it has to be proved that the mentioned pipeline is Piggable.

In fact, that one third of the world's pipelines are 'Unpiggable' and industry seems to just accept this. Surely, with our era of advanced technologies, the number of un-piggable pipelines across the world should be decreasing.

Traditional pigging companies often feel they have nowhere to turn when faced with an Unpiggable pipeline, leaving the client to, either replace, divert, or resort to costly alternatives, such as cutting into the pipeline.

Traditional pigging schemes often require that all conditions are perfect. However, with pipelines getting older, having different diameters, bends, etc. ..., the perfect conditions may be hardly unattainable.

Egypt owned about 20000 Km of different sizes with different services pipeline starting from 42 inch up to 4 inches with huge investment need to be integrated and monitored to keep our assets, putting into consideration its life time since apportion is working more than 50 years

In Line Inspection; (ILI), intelligent pigging or smart pigs are a combination of sophisticated electronic devices utilizing various technologies and including signal sources, sensors to detect various anomalies, can turn the asset management achieved with much more ease.

Smart pigging has taken on an even more critical role with the promulgation of integrity management rulemaking in the last several years. In some situations, smart pigging is not achievable because of the "Unpiggable" term. Pigging companies and clients work to solve these problems and start to, believe that un-piggable pipelines can be outdated.

This thesis reviews the actual types of Unpiggable pipelines, focuses on the criteria of Unpiggable pipelines and practical methods of turning it to into "piggable" or to find some other solutions for proper and efficient inspection. Many case studies are presented and discussed.

Also, to highlight the urgency of establishing an Egyptian organization for pipeline integrity to deal with all procedures and programs to indorse and secure our asset integrity system especially in oil and gas and petrochemical field.

PIG speed is very important parameter in executing pigging activities , to get optimum results lead to improves efficiency of pigging tasks ,also estimating PIG arrival time at receiving station, ,. The objective of this paper is to control the pig speed.
Our point is to reduce pig device velocity by opening slot (s) through the device itself to transfer the flow from rear to front which lead to velocity reduction to get the optimum inspection results through experimental, we achieve positive results as will be discussed

Keywords: **Pipeline, inspection, corrosion integrity, smart pigging, unpiggable, safety.**

1. INTRODUCTION

It is a fact that the growth of international demand for energy resources are going up, and the oil production capacity growing from 80 million barrel/day at 2000 expected to be 110 m b/day by 2020

Crude oil and refined products are transported across the water in tankers and/or underwater pipelines. On land crude oil and products are moved using pipelines, trucks, and sometimes trains. Pipelines are the main 'arteries' of the oil and gas industry, 40 times safer than rail tanks, and 100 times safer than road tanks or offshore tankers. The costs of pipeline transportation are one-third of those for railroad transport Ref (1) (Transportation Systems and Engineering: Concepts, Methodologies, Tools, and applications GI Global, Jun 30, 2015)

A pipeline system is defined as a pipeline section extending from an inlet point (may be an offshore platform or onshore compressor/pump station) to an outlet point (may be another platform or an onshore receiving station).

Pipeline operators are working hardly to improve pipeline safety and reduce the number of pipeline incidents, not standing by or waiting for new safety requirements. pushing forward with new technologies to keep pipelines safe, new methods for inspecting, monitoring, building, and performing preventative maintenance on pipelines, and new systems for managing pipeline safety programs.

The Pipeline Safety Excellence annual report gives an overview of the industry-wide shared pipeline safety principles, the API (Ref2(American Petroleum Institute)and AOPL(Ref 3)API-AOPL Annual Liquids Pipeline Safety Excellence Performance Report &Strategic Plan teams working to improve different aspects of pipeline safety, industry's commitment to annually review pipeline safety performance, and the process to develop a pipeline safety improvement strategic plan by analyzing the industry-wide safety record, including where performance is improving and which areas hold challenges to gain their perspective on improving pipeline safety which reflect the term of pipeline integrity.

Strategic Initiatives developed for 2016 focus on advancing in-line inspection "smart pig" technology and enhancing pipeline emergency response and planning, as well as support implementation of new industry-wide recommended practices for these focuses safety management systems; detecting, analyzing and responding to potential pipeline cracking and managing leak detection programs, pipeline operators are hard at work to improve pipeline safety. It's not be able to satisfy the huge oil and gas needs while some pipelines are out of integration system coverage which is main component of national security

2. PIPELINE SAFETY TREATS

The latest data, in 2016 given by Association of Oil Pipe Lines (AOPL), and American Petroleum Institute (API) through annual Liquids Pipeline Industry Performance Summary indicating that207,800 miles of liquids pipeline cross America delivering crude oil, refined petroleum products and natural gas liquids, 99.9% of crude oil and petroleum products delivered by pipeline reach their destination safely. Pipeline incidents potentially impacting people or the environment are down 52%. While Corrosion effect is down 68% since 1999 till now

Pipeline Integrity:

The big challenge is to keep pipelines safe,, improve their productivity and maximize asset value. This approach called total pipeline integrity.

Traditional methods for pipeline inspection and maintenance:

Radiography, Ultrasonic, And Hydro-test are the most common traditional ways (we call it direct assessment) to inspect the pipelines.

Intelligent pigs are used to provide information about the condition of a pipeline and can be used to locate problem areas. Pumped through the pipeline online and without any disturbance for pipeline operational condition

Intelligent pigs are designed to identify different features or abnormalities as they travel through the pipe. Briefly lists the functionalities for which intelligent pigs are commonly used. API 1160 and NACE RP0102 provide guidelines for selecting the appropriate tool for a given purpose. In this paper, the most commonly used In-Line Inspection (ILI) techniques, methodology and limitations applicable to detecting metal loss and wall thickness measurements are presented.

PIG speed is very important parameter in executing pigging activities , to get optimum resultslead to improves efficiency of pigging tasks ,also estimating PIG arrival time at receiving station, ,. The objective of this paper is to control the pig speed.

Speed changes are greater in gas pipelines due to fluid compressibility and become dangerous for PIG or tube integrity. A bypass allows fluid passage from back to front of a PIG and the device's displacement speed is different from average flow speed. The starting concept for a PIG's body is a cylinder having a central hole to act as a by-pass; the body is supported by polyurethane discs similar to those used in current cleaning PIGs.

Pipeline pig ability

Pipeline Attributes	Category
No pipeline modifications needed Launcher/Receiver installed	Pigable
Minor pipeline modifications required such as temporary launcher/receiver installation	Easy to pig
Pipelines requiring major modifications	Difficult to pig
Other (pipelines attributes not defined)	Impossible to pig

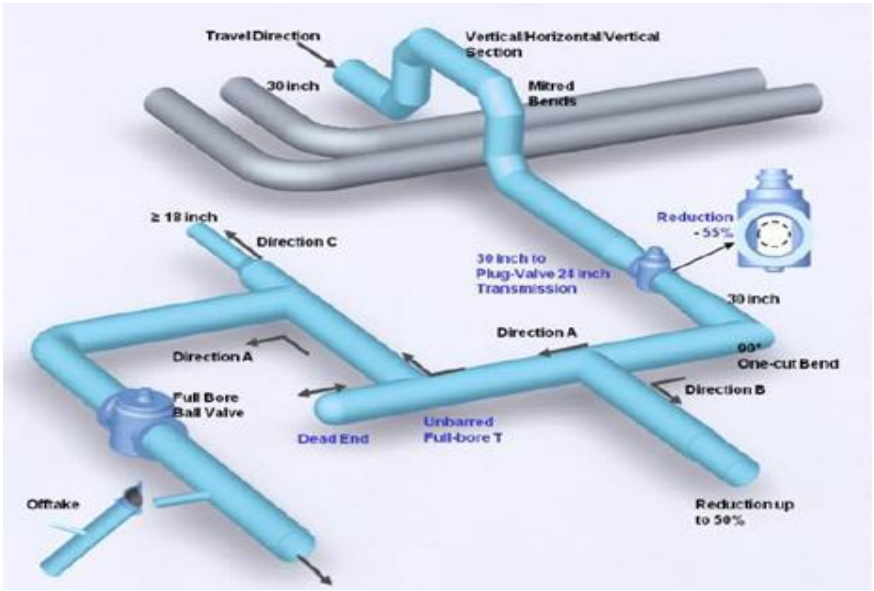
Un-piggable Pipeline:

Pipelines that is difficult to inspect internally with conventional in-line tools such as smart pigs. There are several ways in which mechanical & flow Problems make un-piggable:

1- Mechanical cause:

The multi significant diameters, of the pipe can be restrictive to pigging tools, small diameters with tight bends, repair sections in a different size as well as over- or under-sized valves also Back-to-back bends, and connections can cause a pig to get 'stuck'.

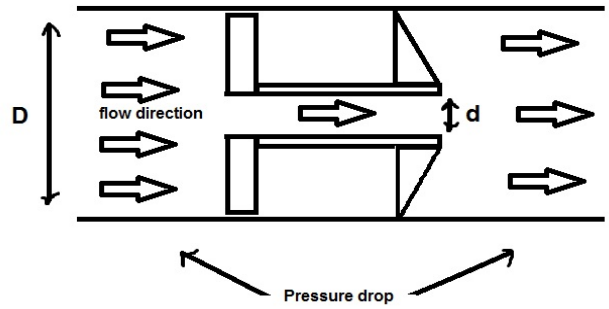
To solve the mechanical obstacles we need to modify the pipeline in nearest shutdown



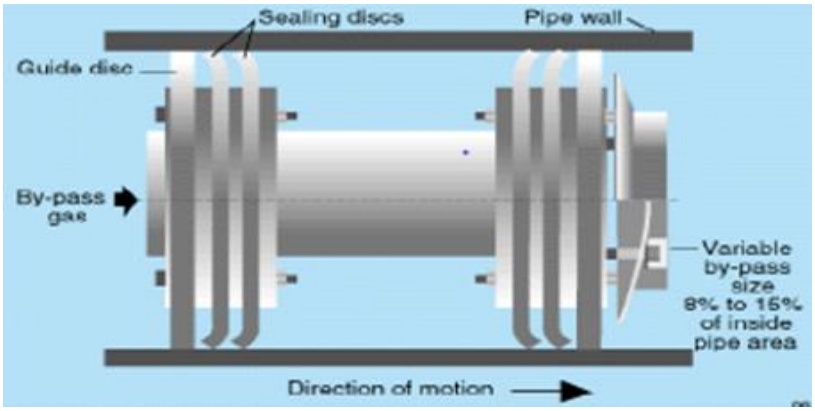
2- Unpiggale due to Flow Problems:

The high velocity flow within a pipeline affects pigging data collection.

We can adapt the velocity by opening slot(s) through the pig device the dimensional flow analyses



$\Delta P = fn(\rho, V, D, \mu, \varepsilon, d, m)$



Dimensional analysis

$\Delta P = fn(L, d, V, \mu, \rho)$

Total no. of variables = 6

$\Delta P = \frac{N}{m^2} = \frac{kg.m}{s^2.m^2} = \frac{kg}{m.s^2} = ML^{-1}T^{-2}$

μ =Pa. s = $ML^{-1}T^{-1}$

$\rho = \frac{kg}{m^3} = ML^{-3}$

$V = \frac{M}{S} = LT^{-1}$

$D = L$

L=L

No. of d L dimension used = 3

No. of repeating variables = 3 (ρ, V, d)

No. of π groubs=$6 - 3 = 3$

$\pi_1 = \rho^a V^b d^c \Delta P$

$\pi_2 = \rho^d V^e d^f \mu$

$\pi_3 = \rho^g V^h d^i L$

$[M^0L^0T^0] = [M^aL^{-3a}][L^bT^{-b}][L^c][ML^{-1}T^{-2}]$

$[M^0L^0T^0] = [M^dL^{-3d}][L^eT^{-e}][L^f][\ ML^{-1}T^{-1}]$

$[M^0L^0T^0] = [M^gL^{-3g}][L^hT^{-h}][L^i][\ L]$

$a = -1\ ,\quad d = -1\ ,\quad g = o$

$b = -2\ ,\quad e = -1\ ,\quad h = 0$

$C = 0\ ,\quad f = -1\ ,\quad i = 1$

$\pi_1 = \frac{\Delta P}{\rho V^2}\ ,\ \pi 2 = \frac{\mu}{\rho V d}\ ,\quad \pi_3 = \frac{L}{d}$

$\pi_1 = fn\left(\frac{1}{\pi^2}, \pi_3\right)\frac{\Delta P}{\rho V^2} = fn\left(\frac{\rho V d}{\mu}, \frac{L}{d}\right)$

Physical meaning: $f = Fn\left(Re, \frac{\varepsilon}{d}\right)$, $hf = f\frac{L}{d}\frac{V^2}{2g}$; hf

3. CONCLUSIONS

Unpiggable pipeline due to high velocity flow can be adapted to be tested by ILI with opening slot(s) through the pig to transfer the flow, and then we can reduce the velocity to be with 3m/sec to obtain the optimum results

Additional challenges for monitoring non-piggable pipelines?

Heavy deposition of wax in- crude oil pipelines.

Deposition of condensate in-case of natural gas pipelines, which speed up internal corrosion rate.

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