Design and construction of a test pipeline for studies of the flow profile of organic fluids using radiotracers

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In the oil industry, the use of pipelines to transport crude oil and its processed products is frequent and widely used not only for transfer between long distances but is also used to move these fluids inside a refinery where pipes are used to move large volumes of crude oil to boilers, heat exchangers and cracking towers.
Simple models consider the flow inside a pipe as a uniform system, but unsteady pipe flow is found during pump oil not only the entrance or the exit length or when the pipe section is changed. Other unsteady flows are obtained when there is a curve or a control valve installed in the pipeline.
Inside a pipe, axial mixing occurs because of two combined effect, advection and diffusion, and to know the real flow profile is essential for a pipe design. These situations interfere in the correct oil flow measurements, normally several flowmeters are installed in the pipeline to monitor the pumping condition and the oil movement.
One of the most used method to measure flow rates is based in the measure of the mean velocity, this is the flow rate Q is the volume V of fluid per unit time flowing through the area A:

$$Q = \frac{V}{t} = \frac{A\,L}{t} = A.v \qquad (1)$$

In equation 1 v is mean velocity of fluid inside the pipe. For Newtonian fluids and low flowrate, the velocity distribution is parabolic, with the fluid in the center moving faster than the fluid near the pipe wall and at high velocities the laminar flow breaks down to become turbulent and the liquid velocity is then no longer axial and takes on random characteristics.
In our tracer laboratory, using a specific radiotracer [1], the oil flowrate inside a pipeline can be accurate measure using the Transient Time [1] method or the Total Count method [3]. All the measurements were done in a test line where different flow conditions can be simulated.

This pipeline was built in PVC and is divided in three different parts. The first one is the pump system and is constituted by an oil pump connected to an electronic system to strictly control the pump velocity and the quantity of oil pumped inside the pipeline. With this system is possible to simulate flows between 20 l/m and 1000 l/m.
Before the injection system there is a calibrated oil flowmeter, OVAL L521231, which can measure oil flowrate between 10l/h and 1000 l/h
The second part is the injection system consist in a bypass in the pipeline controlled by three opened/closed valves. In this bypass there is a reservoir for the labelled oil and two control valves blocking the oil flow through the injection system.
The injection process is done by deposition of the labelled oil (10.00 ± 0.05) ml, inside the injection chamber and the reservoir is closed. The valves are open and a fast tracer pulse is injected in the oil.
The third part is the pipelines where the scintillator detectors are positioned. It consist in two PVC 2" ducts with 13m. In the first oil pipeline there is an oil flow conditioner used to stabilized the oil flow profile and in the second one was installed a reduction made with a ¾" duct to induce a stratification in the flow profile.
In this pipelines several situation can be simulated, using oil labelled with ^{123}I or ^{198}Au the flow properties can be studied, and flowrate for different flow profiles can be measured using both the Transient Time and the Total Count methods.

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