ABSTRACT: This paper presents a new methodology to calculate transportation costs in a long onshore pipe for different "strategic" gases, particularly methane, hydrogen and carbon dioxide. Firstly, we state a physical model of fluid flow in a pipe. Secondly, we consider economic equations model capex and opex according to the pipeline design. The optimisation searches for a global minimum cost of the pipeline design in terms of diameter, thickness and number, position, power of the compressors. The optimisation procedure searches for a global minimum. We present some user cases, particularly comparison of unit transport costs for the three fluids.

KEY WORDS: gas transport, optimum design, lowest cost, pipeline, co2, hydrogen

INTRODUCTION

The need to reduce emissions of greenhouse gases to limit the risks of climate change has now a broad consensus. To be convinced, for example, just read the conclusion of the latest report from the International Energy Agency (IEA), "World Energy Outlook 2008": "Current trends in energy supply and consumption are patently unsustainable - environmentally, economically and socially - they can and must be altered."

Stabilizing greenhouse gas concentration at 550 ppm of co2-equivalent, which would limit the temperature increase to about 3°C, would require emissions to rise to no more than 33 Gt/y in 2030 and to fall in the longer term. On current trends, energy-related co2 emissions are set to increase by 45% between 2006 and 2030, reaching 41 Gt/y.

In this context, the deployment of a low-carbon energy appears as a necessity. Hydropower, nuclear, biomass, other renewable and fossil-fuel power plants equipped with carbon capture and storage (CCS) are some of the different solutions to answer this challenge. Hydrogen is also envisaged for the long term in the transportation sector. These evolutions, particularly CCS and hydrogen for transportation, could lead to the development of new transmission systems: co2 and h2 pipelines, as natural gas networks developed in the past. In this context, it is important to assess the optimal conditions to transport this different fluids.

We center our investigations only to onshore pipelines in standard conditions, concerning particularly economics without taking into account different parameters able to significantly change investments and operating costs (soil type, mountains and river passing through...).

The subject of this paper is to propose a general methodology to find the optimum design that ensures the least cost of a pipeline project. We look for an automatic procedure to point out the better design and we bear particular attention on the way of parametrizing the problem.

The assessment of the losses in a tube is investigated since several centuries and is linked with the understanding of the near-wall layer; see for instance the simplistic formulation in recent papers: Hafner (1994), de Wolf (1996 and 2000); such a formula, presented in Annex, directly links the volume flow rate to the difference of the pressure square between two locations of the axis of the tube.

For compressors, it might be also noticed that some software tools use approximated models including namely fixed ratio whereas Transmin software compute accurately.

This paper is organized as follows. In the first section, the modelling problems are presented, including physical and economical modelling and optimization strategy. A second section looks after a comparison between reference results and our results. Finally, some user cases are presented, namely a strategic case comparing the costs of ch4, co2 and h2 transports.

Modelling Problems

The problem is the following: let A be the location where we have an amount of fluid at our disposal (hydrocarbon wells or manufacturaries) and we want to transport it at a location B where we have consumers. Our purpose is to answer questions about the geometrical design of this pipeline to achieve the lowest cost of implementation, troubleshooting, operating and financial investment. The search for optimality concerns the radius and thickness of the tube, as well as the location, the power and the number of the compressors or pumps and also the financial expenses. Therefore, we need to model the flow in the tube to accurately predict the pressure drop and also the economic mechanisms according to which the exploitation will be