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Original Research Paper

Engineering

OPTIMAL DESIGN OF DIAMETER PIPELINE TRANSMISSION CRUD OIL

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ABSTRACT Pipelines are normally designed to deliver fluid at the required head and flow rate in a cost manner. Increase in conduit diameter leads to increase in annual capital cost, and decrease in operating costs [1]. Determine whether a given pipe flow is laminar or turbulent because there methods of analysis and equations for different flow regime [2].the pipeline system used as case study consists of length , viscosity effect the pipe size in the cost Note that the cost increases with increases the pipe diameter (e.g. 1 to 2 is a doubling, whilst 2 to 3 is only a 50% increase). In this studies notes the pipe is expected to last only 10 years, the lowest cost is for a size 3 pipe. if 20 years use is expected, size 4 gives the lowest cost. This lowest cost size is known as the optimum pipe diameter for the duty given.

KEYWORDS :

INTRODUCTION

A pipeline is a facility through which liquids, gases or solids are transported. Although other forms of transportation are available, pipelines are the safest and most efficient and economic means of transporting crude oil and natural gas from producing fields to connect producers, distributors, and customers [3].Oil and natural gas are transported hundreds of miles by large pipelines .It is deliver natural gas to consumers round the world for the production of heat, electricity, and organic chemicals[4].Proposals to construct, expand, or repurpose pipelines often lead to contention over risks to host communities[4]. Fluid flow is classified as external and internal, depending on whether the fluid is forced to flow over a surface or in a conduit. Internal and external internal flow where the conduit is completely filled with the fluid, and flow is driven primarily by a pressure difference. This should not be confused with open-channel flow where the conduit is partially filled by the fluid and thus the flow is partially bounded by solid surfaces, as in an irrigation ditch, and flow is driven by gravity alone[5].flow liquids, gases in pipline in such applications is forced to flow by a pump or fan through a flow section, which is directly related to friction also to the pressure drop during flow through pipes and ducts. Generally the physical description of internal flow and the velocity boundary layer by dimensionless number . The Reynolds number is dimensionless quantity which it is the ratio of dynamic forces to viscous forces that aids in classifying certain flows[6].the pipe is a hollow cylinder of metal or other material used for the conveyance of water, gas, steam, petroleum and so on, to keep the gas flowing travels through the pipeline necessary to increase the pressure at a number of points along the pipeline Because of the resulting friction due to gas pressure decreases unambiguously if only internal, pressure and viscous effects are involved [3].Reynolds number is the basic parameter determining the flow-field topology and its evolution in time if only inertial, pressure and viscous effects are involved[5]. The physical meaning of Reynolds number vary accordingly, fluid dynamics is to be laminar flow, transition from laminar state to turbulence and fully turbulent . Using extensive steel and metals inside the earth to transport the crud oil for thousands of miles. So in order to minimize the total cost of length of flowline and size of pipe , so Pipelines are normally designed to deliver fluid by flow rate in a cost effective manner .Decrease capital costs, and in operating costs.

Methods and Analysis

Reynolds Number Definition:

Reynolds number is the determining the flow-field topology and its evolution in time denominator the fluid property is present, pressure explanation [7].

Reynolds number could be given by quation [8]:

$$Re = \frac{U \cdot L}{v}$$

Re : Reynolds number ,
U: velocity-scale,
L : length the pipe
ν: viscosity
the fixed or annual pumping cost can be determined using[1];

$$C_l = \frac{P_d C_e Q t}{\rho \eta}$$

Fluid compressibility can be expressed in terms of fluid density as[1].

$$\gamma = \frac{1}{\rho}$$

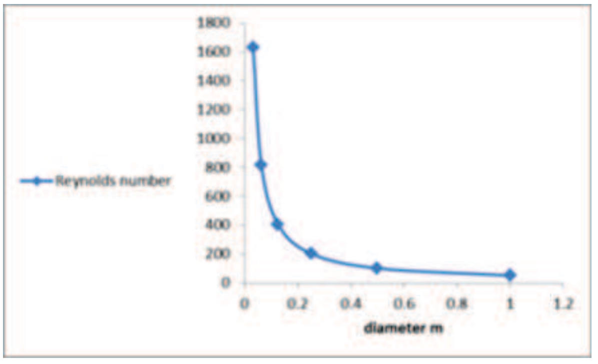
friction factor as the flowing[1] :

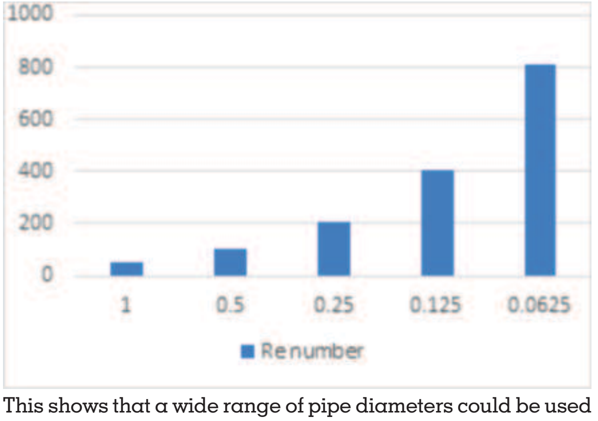
$$f = \frac{0.04}{Re^{0.16}}$$

where:
C_L: the annual pumping cost
P_d : the frictional pressure drop, (kNm-2)
Q = fluid flow rate (kgs^{-1})
C_e:cost of electrical energy, (N kWhr^{-1})
t = operational hours per year; (hr. yr^{-1})
ρ = fluid density, (kgm^{-3})
η = Efficiency of motor and pump, (%)
γ =compressibility, (m3 kg^{-1})
f= fanning friction factor.

Have you ever wondered why there are so many different sized pipes on chemical plants? One obvious reason is that they are carrying different amounts of material, but this is not always the case. In last lectures, we looked at how the value of Reynolds number could be changed by varying the values of velocity and pipe diameter whilst still maintaining the required flow rate., in last lectures we know the pipe diameter of either 1 m or 0.5 m gave Reynolds numbers well below the controlling value of 2000 for streamline flow. The value of pipe diameter could have been further reduced until a figure of nearer 2000 was obtained. In last lectures we also found that the effect of halving the pipe diameter was to quadruple the velocity and double the value of Reynolds number. Therefore, applying this principle in the example shown in last lectures:

pipe Diameter	pipe gives a Reynolds number
1m	50.9
0.5 m	101.8
0.2 5 m pipe	203.6
0.125 m	407.2
0.0625 m	814.4
0.03125 m	1628.8





This shows that a wide range of pipe diameters could be used to give Reynolds numbers below 2000, i.e. streamline flow.

Can you list in the space below any factors you think may be important in helping us decide which of the above pipe diameters would be the best to use.

Factors Affecting The Choice Of Pipe Diameter [3]

1. The pipe diameter must be such that the required flow conditions (streamline or turbulent) are met.
2. The cost of the pipe is important. If a large pipe diameter were chosen, the cost of the pipe would be more than if the pipe diameter were small. The actual difference in cost will depend upon the material of construction, i.e. the dearer the material, the more the extra cost involved in an increase in pipe diameter.
3. A large diameter pipe may cost more to install and takes up more space on the plant. The above three factors (did you get any of these on your list?) tend to suggest that the pipe diameter should be as small as possible – whilst still maintaining the required flow conditions – to minimise the capital costs (the cost of buying and installing the pipe). However, there are two other important factors.
4. The smaller a pipe, the greater the percentage of fluid in contact with the pipe wall. Friction, therefore, increases as pipe diameter decreases since a greater percentage of the fluid feels the effect of this contact. This 'extra' friction is a loss of energy that must be accounted for by supplying more energy to overcome it. Thus the running. Thus the running costs for a small pipe will be greater due to the additional friction..
5. The faster a fluid is flowing, the greater the pressure drop created (see Last lectures on Bernoulli's equation). Therefore, as diameter decreases and the velocity increases to maintain flow conditions, more energy will be required at the pump to overcome the pressure lost during flow and to preserve the required discharge pressure.

The last two factors tend to suggest that as pipe diameter increases, the running costs (the cost of pumping the fluid through the pipe) will reduce, even though there are capital cost benefits arising from keeping pipe diameters to aminimum We have a conflict here between running costs and capital costs, one increasing as the other decreases. Let us look at a simple example to show the principle used in resolving this conflict.

The table below shows the capital costs and running costs/year of five different sized pipes made of the same material, used on the same duty and all giving turbulent flow

SIZE	CAPITAL COST (£)	RUNNING COST/YEAR (£)
1	100	33
2	175	25
3	225	19
4	265	16
5	290	15

Note that the cost figures are not equally spaced. This is because as the pipe size increases, the effect of that increase diminishes (e.g. 1 to 2 is a doubling, whilst 2 to 3 is only a 50% increase). Moreover, the cost of fabrication does not increase at the same rate as size.

Let us now consider the total cost after 10 years use and 20 years use of the above pipes. To obtain total costs, the running cost/year is multiplied by the number of years and added to the capital cost for each size. For example:

SIZE 1

- 10 years running @ 33/year = 330 + 100 (capital cost) = Total cost: 430
- 20 years running @ 33/year = 660 + 100 (capital cost) = Total cost: 760

Try working out the total cost for the other sizes and compare your results with the table shown below.

TOTAL COST

SIZE	10YEARS (£)	20 YEARS (£)
1	430	760
2	425	675
3	415	605
4	425	585
5	440	590

From this table you can see that if the pipe is expected to last only 10 years, the lowest cost is for a size 3 pipe. However if 20 years use is expected, size 4 gives the lowest cost. This lowest cost size is known as the optimum pipe diameter for the duty given.effect the pipe size in the cost Note that the cost increases with increases the pipe diameter (e.g. 1 to 2 is a doubling, whilst 2 to 3 is only a 50% increase). in this studies notes the pipe is expected to last only 10 years, the lowest cost is for a size 3 pipe. if 20 years use is expected, size 4 gives the lowest cost. This lowest cost size is known as the optimum pipe diameter for the duty given.

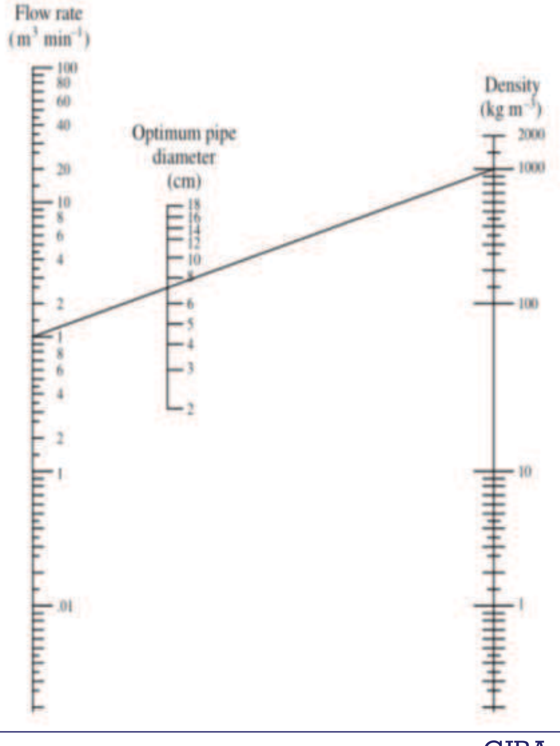
The capital costs increases from 100є to 290є On the other hand the running costs/year of five different sized pipes decreases from 33 to 15є made of the same material, used on the same duty and all giving turbulent flow. the pipe is expected to last only 10 years, the lowest cost is for a size 3 pipe. However if 20 years use is expected, size 4 gives the lowest cost.

CONCLUSION

The optimum pipe diameter is the size of pipe which will give the required flow conditions at the minimum total cost for a given pipe material.But, until now, we've confined our discussions to only one pipe material. What if more than one material could be used for the same duty? We would have to perform calculations similar to that in our example and find the lowest total cost. However, what if the cost of energy increases at the rate of 25% per year? The running cost figures in our example would no longer be correct! What if the capital cost had to be borrowed from a bank and interest rates changed? The capital costs would change! There are clearly many things to be taken into account, including the time taken by an engineer to calculate the optimum diameter. To avoid duplication of work by different engineers, once a calculation for a material has been completed, the engineer produces a chart which is then made available for others to use by publishing in engineering magazines

Note: when a calculation is done, any change in interest rates, costs, etc. is built into the chart. An example of one of these charts for a grade of steel pipe is shown in FIGURE 1. [This chart only applies to turbulent flow, and another similar chart would be used for streamline flow.]

To obtain the optimum diameter, the flow rate required through the pipe is joined by a straight line to the value of the density of the fluid to be pumped. The point where this line crosses the optimum diameter line represents the optimum diameter. However, these charts are based on the cost of standard sized pipe, and so the nearest standard size to the optimum is used. For example, in the case shown in FIGURE 2 the flow required is 1 m3 min-1 and the density of liquid is 1000 kg m--3 . By joining these figures we arrive at an optimum pipe diameter of about 7. This is not a standard size and the correct size to use is the nearest, i.e. 6 or 8. An engineer can use these charts to work out very quickly what size of pipe will do the required duty at the cheapest cost – a very important factor in designing chemical plant.



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