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ME 291 – Engineering Analysis

Project 2

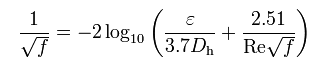
Solving the Colebrook Equation Using the Secant or Newton-Raphson Method.

Abstract

The project goal is to write a program that solves the Colebrook equation (also known as the Colebrook–White equation) for the friction factor. This equation models the behavior of a pipe given various parameters. The parameters are:

1. Roughness of the pipe surface, ε
2. diameter of the pipe, Dh
3. the Reynolds Numbed, Rh

For the scope of this project, the friction factor, f, will not be thought of as a parameter, but rather as an unknown to be calculated.



**Figure 1.** The Colebrook equation

The Program

To implement a solver for the Colebrook equation, the computer programming language C was chosen. The program source code is attached to this submission.

A flow chart of the code was created to visually show how the function works.

Output from Program

Problem number 8.12 from Numerical Methods for Engineers 6th Ed. Was solved using the program written for this project. The pipe diameter is given as 5 mm. The Reynolds Number was calculated to be 13743 (a unitless quantity).

Output from part (a) epsilon = 0.0015 mm

Friction factor = 0.028977

Success = true.

Output from part (b) epsilon = 0.045 mm

Friction factor = 0.040761

Success = true.

How do the following terms affect the friction factor of the pipe?

Re (Reynolds Number)

When the Reynolds Number decreases, the friction factor increases. The two parameters negatively correlated. The website, *The Engineering ToolBox,* says that“The Reynolds Number can be defined as the ratio of the inertia force to the friction force.” With this in mind, it makes sense that the friction factor is negatively correlated to the Reynolds Number as the Reynolds number is inversely proportional to the friction force.

Ultimately, the Reynolds number expresses the relative magnitude of the inertial forces to the frictional forces. Because of this, when the Reynolds Number increases, the friction factor decreases as the magnitude of the inertial force of the fluid is greater than the friction force. This is, again, the conclusion that is intuitively made from observing the ratio of different fluid properties the Reynolds Number is synthesized from.

D (pipe diameter)

When the pipe diameter decreases, the friction factor increases. The two parameters are negatively correlated. This effect is expected as the pipe diameter will force a greater percentage of the fluid flowing through it to be in contact with the inner surface of the pipe.

If the pipe had a larger diameter, then a smaller relative amount of the fluid would be touching the inside surface of the pipe. As the pipe gets larger, the less the pipe surface effects the flow of the liquid because there is more and more fluid that is not touching the surface.

epsilon (roughness)

When the roughness of the pipe material increases, the friction factor increases as well. This means that the two parameters are positively correlated. This makes sense intuitively as the roughness corresponds to the friction of the surface. The friction factor is directly related to the friction of the inside surface of the pipe.

With more friction on the inside surface of the pipe, there would be more resistance to fluid flow in that edge region. And with the fluid at the edges flowing at a different rate than the fluid in the center of the pipe, it is conceivable that turbulence would be a side effect. Furthermore, any turbulence in the flow of water would slow down the average flow rate.

Sources

The Engineering ToolBox, *Reynolds Number*

<http://www.engineeringtoolbox.com/reynolds-number-d\_237.html>