ECOR 1606 Final Lab Test v39

Methane flows isothermally (at a constant temperature, T) through a pipe of length L and inside

diameter D. The pressure at the start of the pipe is p1, and the pressure at the end of the pipe is p2.

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>>>>p1 |||||||||||||||||||||>> p2

In general, increasing p1 will increase the mass flow (m& ) through the pipe. At some point,

However, the flow will become "choked", and further increases in p1 will not increase the mass

flow. The following equations apply:

formula:

if the flow is choked: …..

if the flow is not choked:?

formula: d^2/4 ... suquare root of ,,,,

something times something over 4 times square root of numerator by denominator 2+ln///..

?

?

??

?

+

-

=

1 2

2

2

2

1

2

2ln >> it has lexponent log/

4

p p

D

fL

RT

D p p

m

p &

(2)

where m is the mass flow (in kg/s)

L and D are the length and diameter of the pipe (in m)

p1 and p2 are the pressures at the start and end of the pipe (in Pa)

R is the gas constant for methane (518 m2/s2-K)

T is the temperature of the flow (in K, assume 300K)

f is the average friction factor (dimensionless)

Important notes:

· **Remember the difference between log and ln (i.e. log base e). Here we want log base e** --

see your crib sheet.

· Use M\_PI for p.

The average friction factor ( f ) in the second equation is related to the mass flow rate by

F= something something where u is viscocity;

where µ is the viscosity of methane (1.34x10-5 N-s/m2)

When using equation (2) to calculatem& , f is initially given some arbitrary value (use 0.025),

then the calculated value of m& and equation (3) are used to calculate a better f . Then the new

f and equation (2) are used to calculate a better m& , and so on until the changes in m& become

acceptably small.

The flow is choked if the mass flow given by equation (2) is greater than or equal to the mass

flow given by equation (1).

Write a C++ program (“v39.cpp”) that repeatedly reads in D, L, p1 and p2 until 0 0 0 0 is entered.

D and L should be read in metres, and p1 and p2 in kPa (i.e. kiloPascals). Note that the

formulae require pressures in Pa, i.e. Pascals. For each set of values entered, your program

should either i) output an error message (if the values are unreasonable -- see next paragraph) or

ii) output the corresponding mass flow rate and a message indicating whether or not the flow is

choked.

Input values should be rejected if any of D, L, and p2 are less than or equal to zero, or if p1 is less

than or equal to p2.

Your program must include and use the following two functions:

1. A function that, given D, L, p1, and p2, computes and returns m& assuming that the flow is

not choked. After using f = 0.025 to calculate an initial value form& and printing this

out, your function should keep applying equations (3) and (2) and printing the results (see

test run below) until the percentage change in m& (see next line) is less than 0.01.

% change ´100%

Mold-mnew/ m x100 <<< change %

2. A function that, given D and p2, computes and returns m& assuming that the flow is

choked.

How it should look like::

***Test Run***

***Enter D, L, p1, and p2 (zeroes to terminate): 0.1 100 200 100***

***for the initial f value of 0.025 m = 0.671794***

***using this value for m gives f = 0.0111938***

***using this value for f gives m = 0.972935, % change = 44.8264***

***using this value for m gives f = 0.0102039***

***using this value for f gives m = 1.01363, % change = 4.183***

***using this value for m gives f = 0.0100999***

***using this value for f gives m = 1.01821, % change = 0.451707***

***using this value for m gives f = 0.0100885***

***using this value for f gives m = 1.01872, % change = 0.0495457***

***using this value for m gives f = 0.0100872***

***using this value for f gives m = 1.01877, % change = 0.00544376***

***The flow is not choked. The mass flow is 1.01877 kg/sec.***

***Enter D, L, p1, and p2 (zeroes to terminate): 0.1 100 500 100***

***for the initial f value of 0.025 m = 1.83738***

***using this value for m gives f = 0.00870433***

***using this value for f gives m = 2.82666, % change = 53.8415***

***using this value for m gives f = 0.00781568***

***using this value for f gives m = 2.93828, % change = 3.94869***

***using this value for m gives f = 0.00774038***

***using this value for f gives m = 2.94835, % change = 0.342979***

***using this value for m gives f = 0.00773375***

***using this value for f gives m = 2.94924, % change = 0.0302291***

***using this value for m gives f = 0.00773317***

***using this value for f gives m = 2.94932, % change = 0.00266774***

***The flow is choked. The mass flow is 1.99234 kg/sec.***

***Enter D, L, p1, and p2 (zeroes to terminate): 1 10 500 100***

***for the initial f value of 0.025 m = 524.053***

***using this value for m gives f = 0.00376653***

***using this value for f gives m = 540.869, % change = 3.20865***

***using this value for m gives f = 0.00373691***

***using this value for f gives m = 540.893, % change = 0.00454838***

***The flow is choked. The mass flow is 199.234 kg/sec.***

***Enter D, L, p1, and p2 (zeroes to terminate): 0.5 1000 500 100***

***for the initial f value of 0.025 m = 33.4485***

***using this value for m gives f = 0.00630135***

***using this value for f gives m = 61.3459, % change = 83.4037***

***using this value for m gives f = 0.00541479***

***using this value for f gives m = 65.1022, % change = 6.12326***

***using this value for m gives f = 0.00533493***

***using this value for f gives m = 65.4755, % change = 0.573333***

***using this value for m gives f = 0.00532731***

***using this value for f gives m = 65.5114, % change = 0.0549058***

***using this value for m gives f = 0.00532658***

***using this value for f gives m = 65.5149, % change = 0.00526945***

***The flow is choked. The mass flow is 49.8086 kg/sec.***

***Enter D, L, p1, and p2 (zeroes to terminate): 0.5 1000 300 100***

***for the initial f value of 0.025 m = 19.4996***

***using this value for m gives f = 0.00721143***

***using this value for f gives m = 34.5567, % change = 77.2177***

***using this value for m gives f = 0.00625021***

***using this value for f gives m = 36.7473, % change = 6.33904***

***using this value for m gives f = 0.0061549***

***using this value for f gives m = 36.9879, % change = 0.654806***

***using this value for m gives f = 0.00614487***

***using this value for f gives m = 37.0135, % change = 0.0692427***

***using this value for m gives f = 0.00614381***

***using this value for f gives m = 37.0163, % change = 0.00734023***

***The flow is not choked. The mass flow is 37.0163 kg/sec.***

***Enter D, L, p1, and p2 (zeroes to terminate): 0 100 200 100***

***\*\*\* Invalid values ignored. \*\*\****

***Enter D, L, p1, and p2 (zeroes to terminate): 0.1 0 200 100***

***\*\*\* Invalid values ignored. \*\*\****

***Enter D, L, p1, and p2 (zeroes to terminate): 1 100 0 100***

***\*\*\* Invalid values ignored. \*\*\****

***Enter D, L, p1, and p2 (zeroes to terminate): 0.1 100 200 0***

***\*\*\* Invalid values ignored. \*\*\****

***Enter D, L, p1, and p2 (zeroes to terminate): 0.1 100 -10 -20***

***\*\*\* Invalid values ignored. \*\*\****

***Enter D, L, p1, and p2 (zeroes to terminate): -0.1 1 200 100***

***\*\*\* Invalid values ignored. \*\*\****

***Enter D, L, p1, and p2 (zeroes to terminate): 1 100 100 100***

***\*\*\* Invalid values ignored. \*\*\****

***Enter D, L, p1, and p2 (zeroes to terminate): 0 0 0 0***

***Press any key to continue . . .***