Summary

By measuring pressure loss and flow rate in rough pipe, pipe friction would be calculated. After choosing the pipe, measure diameter, and all valve apart from the concerned one are closed. Reynolds number depends on mean fluid velocity, pipe diameter, fluid density and dynamic viscosity. Pressure drops and temperatures are measured in steady state. Density and dynamic viscosity are calculated by Table 1. Flow Rate could be find out by Figure 1. Mean fluid velocity are calculated by Equation(3). If Reynolds number is smaller than 2,000, the flow would be normally laminar flow, otherwise it would be turbulent. Friction would be found by Equation(4) and (5).

Compare experimental and theoretical values of friction to check the accuracy.By knowing the friction of a pipe therefore the pressure drop and the flow rate, it would be possible to estimate the pumping power for fluid through a given pipe network.

Answer to the following questions:

Q1 - *Why do you have discrepancies between experimental data and the Moody curves?*

There would be certain measurement errors affecting the results. The values of viscosity would be inaccurate as the number was calculated by estimating form its neighbour values., and even though it was regressed and has its best estimation, there would still be difference.

Q2 - *Provide a list of possible sources of the measurement errors and propose solutions to minimize them (discrepancies).*

The actual temperature of the water may vary due to heat loss during the pipe flow, which would therefore affect the value of viscosity. The environment temperature could be match the liquid temperature to minimize heat loss, or use resistive material to cover the pipe.

Use of Matlab to do the line regression of datas from Table 1 to minimize the difference between the demanded values of density and viscosity, instead of simply use linear estimation for the values.

It is assumed that the fluid used for the pipe flow was incompressible and pipes were entirely horizontal with the same diameters throughout the testing region, and smooth. In reality it would be hard to achieve. Several measurements could be taken before the experiment to ensure the accuracy. Polishing the pipe could help to reduce the error.

It would be better to take more measurements for differed pressure drop, as providing a better figure for regression, thus the friction coefficient would be better determined, and the margin of error would be smaller, because one or two inaccurate points could be disregarded with a larger data sample.

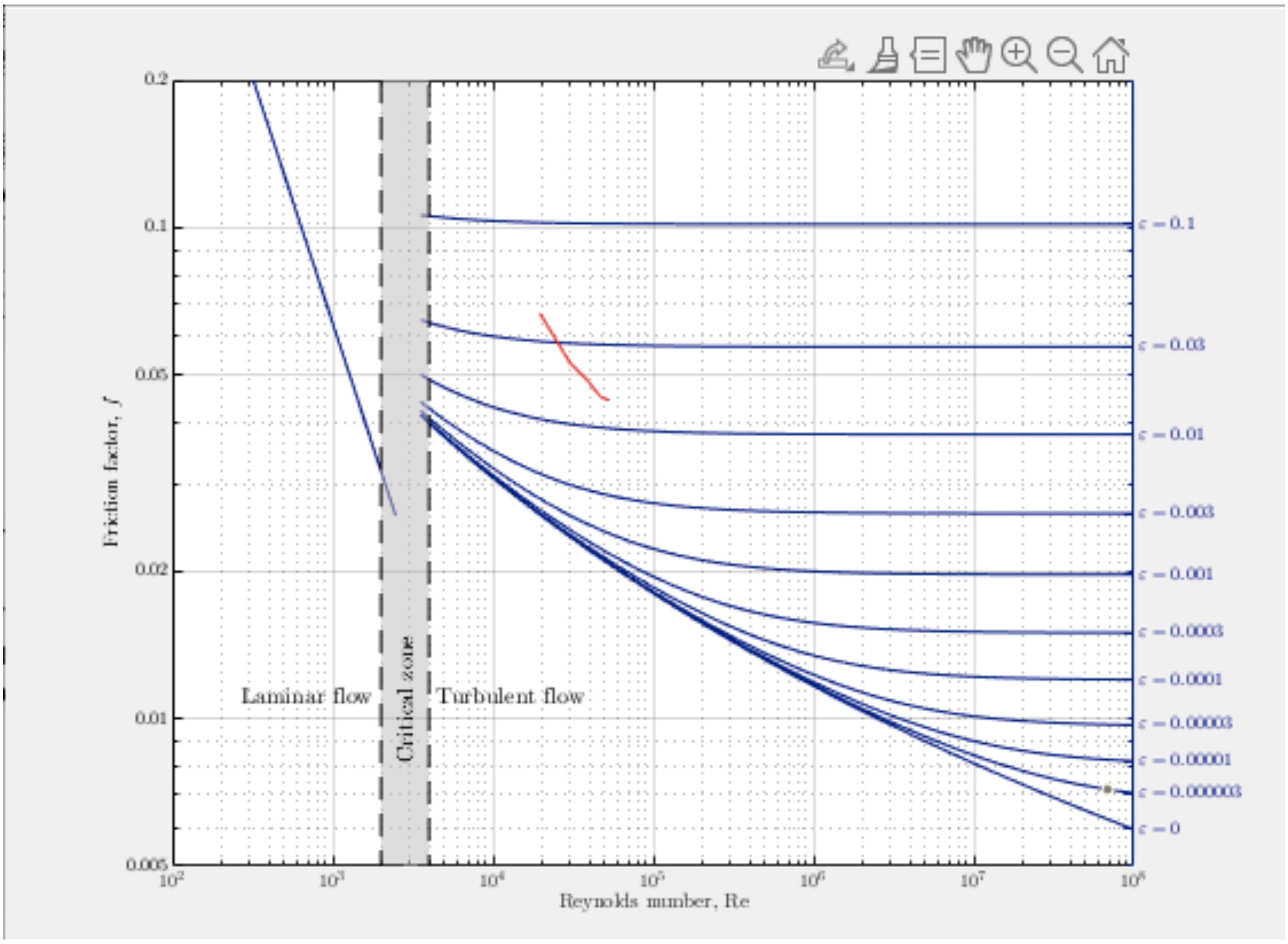
Q3 - *If you had a smooth pipe instead of a rough pipe, how will it affect the flow pumping power?*

The friction factor of the rough pipe could be much more than the smooth pipes, therefore a lower pumping power would be needed for a smooth pipe.

Conclusion (not more than 150 words)

In general case, the material could be Cast iron-asphalt dipped, or Galvanized iron. For future investigations, it would be better to take more measurements for differed pressure drop, so that the friction coefficient could be determined as a clearer number, thus the exact material could be therefore figured out. In conclusion, the results shows a positive relation between roughness and pumping power needed, although four datas would not be enough to give any mathematical relationship.

Plot of Moody chart and experimental value in Matlab is achieved, where I found difficult to plot the graph manually, so digital plots were applied.


Friction factor, f
Reynolds number, Re
Laminar flow
Critical zone
Turbulent flow
ε = 0.1
ε = 0.03
ε = 0.01
ε = 0.003
ε = 0.001
ε = 0.0003
ε = 0.0001
ε = 0.00003
ε = 0.00001
ε = 0.000003
ε = 0

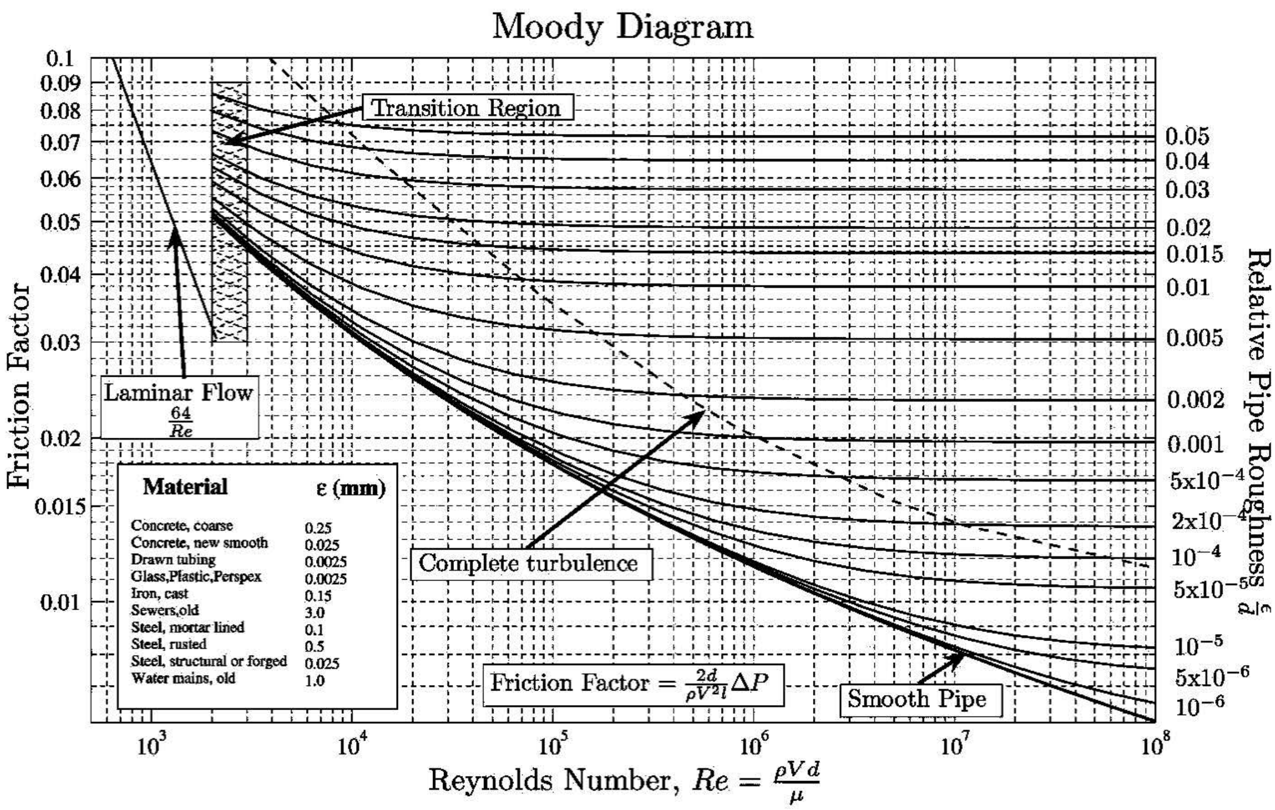

Moody Diagram
Transition Region
Laminar Flow
64/Re
Complete turbulence
Friction Factor = $\frac{2d}{\rho V^2 l}\Delta P$
Smooth Pipe
Friction Factor
Relative Pipe Roughness $\frac{\epsilon}{d}$
Reynolds Number, $Re = \frac{\rho V d}{\mu}$
Material ε (mm)
Concrete, coarse 0.25
Concrete, new smooth 0.025
Drawn tubing 0.0025
Glass,Plastic,Perspex 0.0025
Iron, cast 0.15
Sewers,old 3.0
Steel, mortar lined 0.1
Steel, rusted 0.5
Steel, structural or forged 0.025
Water mains, old 1.0

Table 2: RESULTS DATASHEET

Data collected by ZTT Tuesday 20/10/2020.

ES2C5 **PIPE FLOW EXPERIMENT**

Pipe type: ***Large & Rough*** **Outer Diameter (m):** 0.01920

Pipe length (m): 1 **Inner Diameter D (m):** 0.01355

Test No	1	2	3	4	5
Temperature (oC)	20.3	20.4	20.2	20.1	20.0
Pressure Drop (KPa)	5.14	9.60	14.98	20.01	25.57
Density ρ (kg/m3)	998.195	998.174	998.215	998.235	998.256
Dynamic viscosity η (Pa.s)	0.994*10^-3	0.991*10^-3	0.996*10^-3	0.999*10^-3	1.001*10^-3
Flow rate Q (m3/s)	0.208*10^-3	0.319*10^-3	0.417*10^-3	0.500*10^-3	0.569*10^-3
Um (m/s)	1.44	2.22	2.89	3.47	3.95
Re	1.97*10^4	3.02*10^4	3.92*10^4	4.70*10^4	5.34*10^4
f	0.0669	0.0531	0.0487	0.0452	0.0445

Relative Roughness ε/D	0.01
Roughness ε (μm)	135.5

Figure 3: Water flow calibration graph