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In engineering, the **Moody chart** or **Moody diagram** (also **Stanton diagram**) is a graph in non-dimensional form that relates the Darcy–Weisbach friction factor *f*_D, Reynolds number *Re*, and surface roughness for fully developed flow in a circular pipe. It can be used to predict pressure drop or flow rate down such a pipe. Moody diagram showing the Darcy–Weisbach friction factor *f*_D plotted against Reynolds number *Re* for various relative roughness ϵ / D History In 1944, Lewis Ferry Moody plotted the Darcy–Weisbach friction factor against Reynolds number *Re* for various values of relative roughness ϵ / D .^[1] This chart became commonly known as the Moody chart or Moody diagram. It adapts the work of Hunter Rouse^[2] but uses the more practical choice of coordinates employed by R. J. S. Pigott,^[3] whose work was based upon an analysis of some 10,000 experiments from various sources.^[4] Measurements of fluid flow in artificially roughened pipes by J. Nikuradse^[5] were at the time too recent to include in Pigott's chart. The chart's purpose was to provide a graphical representation of the function of C. F. Colebrook in collaboration with C. M. White,^[6] which provided a practical form of transition curve to bridge the transition zone between smooth and rough pipes, the region of incomplete turbulence. Description Moody's team used the available data (including that of Nikuradse) to show that fluid flow in rough pipes could be described by four dimensionless quantities: Reynolds number, pressure loss coefficient, diameter ratio of the pipe and the relative roughness of the pipe. They then produced a single plot which showed that all of these collapsed onto a series of lines, now known as the Moody chart. This dimensionless chart is used to work out pressure drop,

Δ
p

{\displaystyle \Delta p}

 (Pa) (or head loss,

h

f

{\displaystyle h_{f}}

 (m)) and flow rate through pipes. Head loss can be calculated using the Darcy–Weisbach equation in which the Darcy friction factor

f

D

{\displaystyle f_{D}}

 appears :

h

f

=

f

D

L
D

V

2

2
g

;

{\displaystyle h_{f}={\frac {f_{D}}{2g}}V^{2}{\frac {L}{D}};}

 Pressure drop can then be evaluated as:

Δ
p
=
ρ
g

h

f

{\displaystyle \Delta p=\rho \,g\,h_{f}}

 or directly from

Δ
p
=

f

D

ρ

V

2

2
L
D

,

{\displaystyle \Delta p={\frac {\rho V^{2}}{2}}{\frac {L}{D}},}

 where

ρ

{\displaystyle \rho }

 is the density of the fluid,

V

{\displaystyle V}

 is the average velocity in the pipe,

L

{\displaystyle L}

 is the friction factor from the Moody chart,

L

{\displaystyle L}

 is the length of the pipe and

D

{\displaystyle D}

 is the pipe diameter. The chart plots Darcy–Weisbach friction factor

f

D

{\displaystyle f_{D}}

 against Reynolds number *Re* for a variety of relative roughnesses, the ratio of the mean height of roughness of the pipe to the pipe diameter or

ϵ

/

D

{\displaystyle \epsilon /D}

. The Moody chart can be divided into two regimes of flow: laminar and turbulent. For the laminar flow regime (

R

e

{\displaystyle Re}

 < ~3000), roughness has no discernible effect, and the Darcy–Weisbach friction factor

f

D

{\displaystyle f_{D}}

 was determined analytically by Poiseuille:

f

D

=
64

/

R

e

,

{\displaystyle f_{D}=64/\mathrm {Re} ,}

(
text
{
for
laminar
flow
}
)
.

{\text{for laminar flow}}

 For the turbulent flow regime, the relationship between the friction factor

f

D

{\displaystyle f_{D}}

, the Reynolds number *Re*, and the relative roughness ϵ / D

(
{\displaystyle \epsilon /D}

 is more complex. One model for this relationship is the Colebrook equation (which is an implicit equation in

f

D

{\displaystyle f_{D}}

):

1

f

D

=
−
2.0
log

10

(
ϵ

/

D

3.7

+
2.51

R

e

f

D

)
,

{\displaystyle (1/\sqrt {f_{D}})=-2.0\log _{10}\left({\frac {\epsilon /D}{3.7}}+{\frac {2.51}{\mathrm {Re} {\sqrt {f_{D}}}}}\right),}

(
text
{
for
turbulent
flow
}
)
.

{\text{for turbulent flow}}

 Fanning friction factor This formula must not be confused with the Fanning equation, using the Fanning friction factor

f

{\displaystyle f}

, equal to one fourth the Darcy–Weisbach friction factor

f

D

{\displaystyle f_{D}}

. Here the pressure drop is:

Δ
p
=
ρ

V

2

2
4

f

L
D

,

{\displaystyle \Delta p={\frac {\rho V^{2}}{2}}{\frac {4fL}{D}},}

 References ^ Moody, L. F. (1944). "Friction factors for pipe flow" (PDF). Transactions of the ASME, 66 (8): 671–684, archived (PDF) from the original on 2019-11-26 ^ Rouse, H. (1943). Evaluation of Boundary Roughness. Proceedings Second Hydraulic Conference, University of Iowa Bulletin 27. ^ Pigott, R. J. S. (1933). "The Flow of Fluids in Closed Conduits". Mechanical Engineering. 55: 497–501, 515. ^ Kemler, E. (1933). "A Study of the Data on the Flow of Fluid in Pipes". Transactions of the ASME. 55 (Hyd-55-2): 7–32. ^ Nikuradse, J. (1933). "Strömungsgesetze in Rauhen Rohren". V. D. I. Forschungsheft. Berlin. 361: 1–22. These show in detail the transition region for pipes with high relative roughness ($\epsilon / D > 0.001$). ^ Colebrook, C. F. (1938–1939). "Turbulent Flow in Pipes, With Particular Reference to the Transition Region Between the Smooth and Rough Pipe Laws". Journal of the Institution of Civil Engineers. London, England. 11 (4): 133–156. doi:10.1680/ijoti.1939.13150. See also Friction loss Darcy friction factor formulae Retrieved from "

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