Ain Shams University
Faculty of Engineering

EFFECT OF TEMPERATURE ON PRESSURE LOSS IN PIPE BENDS.

THESIS

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By

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PREFACE

This thesis is presented in part fulfilling of a degree of Master of Science to the Faculty of Engineering, Ain Shams University.

Neither part nor all of this work has been submitted for a degree in any other University.

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بسم الله الرحمن الرحيم

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SUMMARY

The problem of determining the pressure loss produced by pipe-bends has been investigated for many years, for its considerable importance in the design and analysis of fluid-machinery and piping systems. However, although many investigators have studied the problem, the results obtained did not show satisfactory correlation.

One of the recent published work gave a consistent method of computing pressure loss in bends, but only for isothermal flow.

The present work was carried out to show the effects of change in fluid temperature, relative radius of curvature, and Reynold's number on the bend resistance besides constant relative roughness of the pipe wall with constant angle of deflection equal 90-deg.

The results obtained show, the following:

(a) For a straight pipe lines, no effect for the variation of the temperature on the relation between the coefficient of friction and Reynold's number, i.e. heat transfer from the air has no effect on the coefficient of friction and Reynold's number. x within the range of the test.

(b) For curved pipes with angle of defelction 90-deg.:

- For a certain bend at the same Reynold's number, the total bend-loss coefficient decreases as the mean air temperature increases
- For the same Reynold's number and temperature, the total bend-loss coefficient increases as the radius of curvature increases.

From both theoretical and experimental analysis, a new nondimensional number is used in the final formula which deals with the total bend-loss coefficient and the factors mentioned above.

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NOMENCLATURES

SYMBOL	DESIGNATION
A	Crossectional area, m^2
C_d	Coefficient of discharge.
C_f	Correction factor.
$d=2r$	Internal diameter of pipe, m
f	Friction factor for a straight pipe.
f_c	Friction factor for a curved pipe.
g	Acceleration of gravity, m/sec^2
h	Loss of head, mm H_2O
K_t	Total Bend-loss coefficient defined by equation (3.1)
K	Bend-loss coefficient measured with the region of the propagated disturbance, as defined by equation (3.2).
K_c	Bend-loss coefficient measured at exit of bend, as defined by equation (3.3).
K_s	Loss coefficient for a straight pipe of the same axial length as bend.
k	Constant, determined experimentally.
K	Thermal conductivity of air, K.cal/mhr°.
L	Length, m
ℓ_c	Axial length of center line of bend, m

SYMBOL	DESIGNATION
ℓ_u	Length of the upstream tangent, m
ℓ_d	Length of the downstream tangent, m
m	Constant, determined experimentally.
n	The power of velocity distribution low.
N_u	Nusselt number
P	Atmospheric pressure, mmHg.
q	Rate of heat transfer per unit length of the pipe, K.cal/hr $\dot{m}$
r	Radius of circular cross section of pipe, m
R	The air constant, Kp.m/Kg°
R	Radius of center line of bend, m
R_N	Reynolds number
t	Air temperature, °C
T	Absolute air temperature, °K
$\bar{u}$	Mean axial flow velocity, m/sec.
U	Center line velocity, m/sec
x,y,z	The cartesian co-ordinates, m
α	Numerical factor determined by equation (3.5) to (3.6)
γ	Constant, determined experimentally.
δ	Constant, determined experimentally

SYMBOL	DESIGNATION
Δ	Difference between K_t & K_s (Fig. 23).
ζ	Difference between K_t & K_s (R_N = const.)
θ	Deflection angle of bend, radians
Ω	Vortex, m^2/sec.
μ	Dynamic viscosity of fluid, Kg.sec/m^2
ν	Kinematic viscosity of fluid, m^2/sec.
ρ	Density of fluid, Kg/m^3
τ	Unit shear stress at the pipe wall, Kp/m^2
ϕ	Angle measured in y-z plane from the y-axis.
ω	Vorticity, 1/sec.
P_r	Prandtl number.
G_r	Grashof number

Suffices:

0	Orifice conditions.
1	Upstream condition.
2	Downstream condition.
m	Mean value
st	Standard conditions for the air which are: P = 760 mmHg. t = 20°C
w	Wall conditions.
c	Curved pipe.
s	Secondary.

INTRODUCTION

The problem of determining the pressure loss in a bend has been the subject of researches for many years, because of its considerable engineering importance in the design and analysis of fluid machinery and piping systems.

However, although many investigators have studied the problem, it remains open for further investigations.

Published formulae by R.J.S. Pigott [14] in 1950, have given results which are in considerable quantitative disagreement. It is evident that a more detailed study is necessary before his results could have a certain systematic basis.

H. Ito [10] 1960, furnished a more rational and consistent method for computing the loss of head due to pipe bends, however, the scatter of his results appears to be too large to be attributed to expermintal reasons.

The work discussed by H. Ito [10] was undertaken to obtain information which would be of some help with the correlation of previous results, and, further, to furnish some accurate data for engineering use.

The present work contains the most important effects as applied to bend resistance. These effects are:

(1) Change in temperature.

(2) Relative radius of curvature.

(3) Reynold's number.

The emperical formula established in the present work containing such variables is backed by theoretical considerations shows the effect of temperature and heat transfer on the coefficient of friction in both of straight pipe and curved pipes of different curvatures.

Air in the incompressible range was used as a working fluid for the present work.

The aim of the present work is not however, aiming towards establishing a new emperical formula for computing the loss due to pipe bends which may be used under all circumstances, but, to furnish an emperical formula which will be of some help with the correction of the bend-loss coefficient, and further, to draw attention to the importance of the pressure losses that take place in the downstream tangent and the air temperature (i.e. the effect of heat transfer).

Although the experiments to be discussed are limited to the case of constant relative roughness pipe bends and constant angle of deflection, the results may give closer definition to the present outlines of the laws of bend resistance.