ZEUSNUMERIX

Air Knife Design

USER MANUAL

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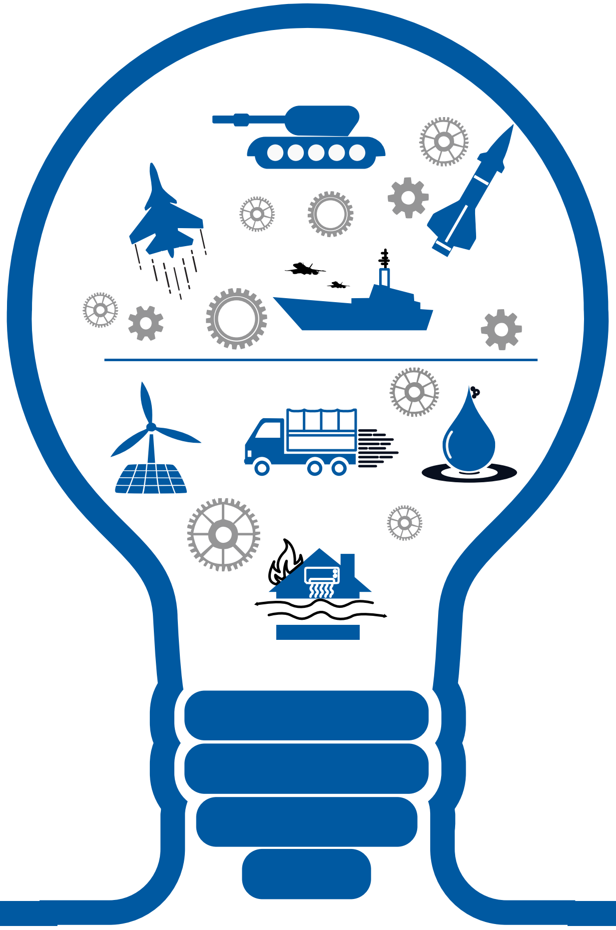


Build-to-Specifications | Product Approval | Engineering Services | Software Development

Contents

Introduction

- This C++ code is a useful tool for designing an air knife for frost removal purposes.
- In this tool, the user needs to input the specifications and properties for the blower, ducts and nozzle (air knife) in the provided format.
- Code takes input file and extracts data from it. Input data is used to perform calculations related to flow conditions (such as pressure drops, dynamic pressure, etc.)
- Various parameters like the flow rate of air knife, total pressure drop in the circuit, exit velocity and the variation of centerline velocity are obtained as results.

APP Usage guide

INPUTS:

- Download Sample input file
- Edit it as per requirements
- Upload to input file to App webpage

EXECUTION:

- Run the App by hitting Run button
- App will perform the background calculations as described later in this manual

OUTPUT:

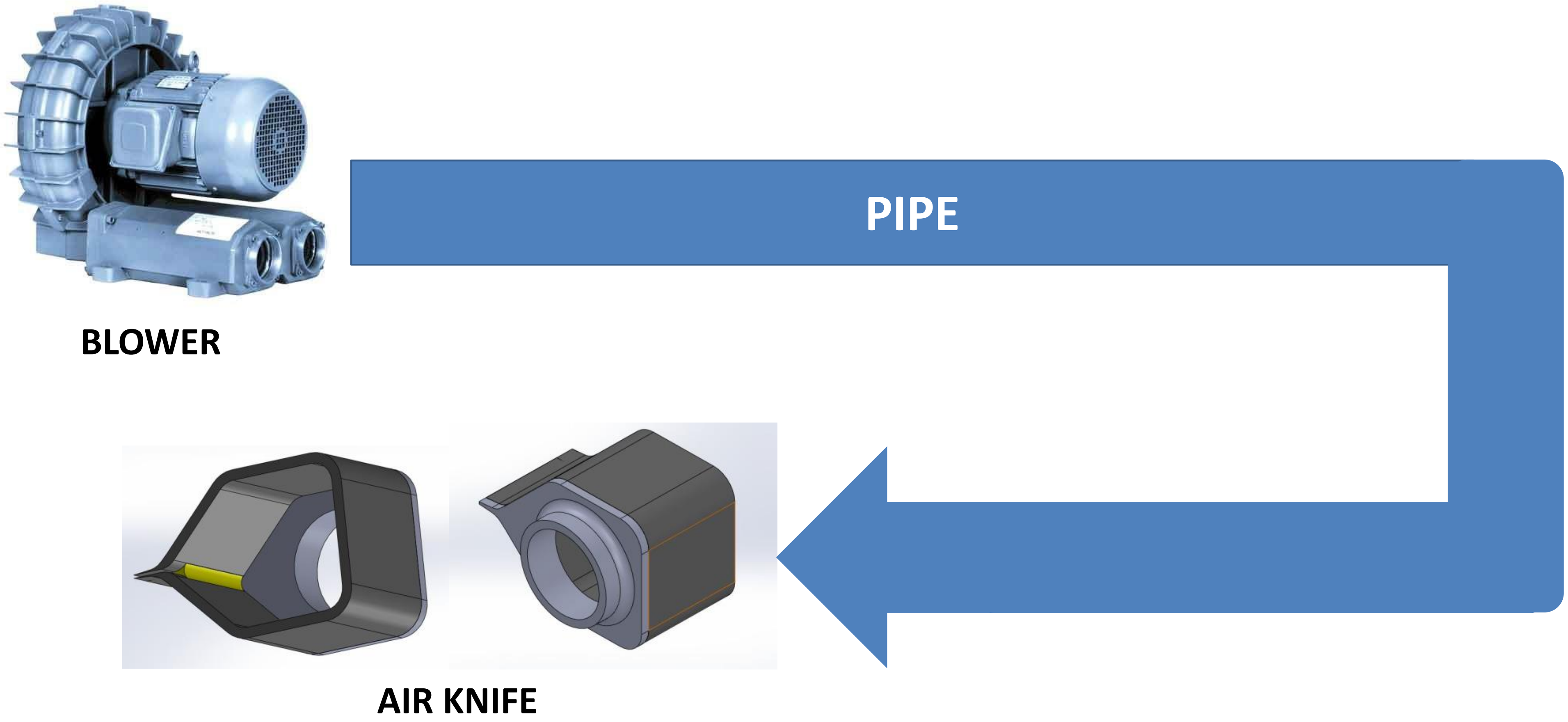
- After execution , output will be shown on the screen.
- To download output file, hit the Download Button

Abbreviations

Following abbreviation are used in Input and Output files:

- blower_max_pressure – Maximum pressure inside the blower (in Pa).
- blower_max_flow_rate – Maximum flow rate from the blower (in m3/hr).
- hose_diameter – Diameter of hose pipe (in inches).
- hose_length – Length of hose pipe (in metres).
- nozzle_slit_length – Length of nozzle (in mm).
- nozzle_slit_gap – Gap in the nozzle slit (in mm).
- number_of_bends – Number of bends in the pipe.
- velocityNozzle – Exit velocity from the nozzle.

Schematic of the setup



Input file Information

Input file needs following data (units specified in the brackets):

- Specifications for the blower:

  "blower_max_pressure = 25000" (in Pa)

  "blower_max_flow_rate = 500" (in m^3/hr)

- Specifications of hose pipe:

  "hose_diameter = 3" (in inches)

  "hose_length = 2" (in metres)

  "number_of_bends = 2"

Input file Information

- Specifications for the nozzle (air knife):

"nozzle_slit_length = 1200" (in mm)

"nozzle_slit_gap = 1.5" (in mm)

- Loss coefficients and other factors:

"loss_hose_friction = 0.045"

"loss_coeff_bend = 0.5"

"loss_coeff_nozzle = 0.2"

"relaxation = 0.9"

Useful Equations

Calculate the area of pipe and nozzle (in m^2):

$$hoseArea = 0.25 * \pi \, (hoseDiameter * 0.0254)^2$$

$$nozzleArea = \frac{nozzleSlitGap * nozzleSlitLength}{100000}$$

Initial flow rate from the blower (in m^3/s):

$$flowRateFromBlower = \frac{0.5 * blowerMaxFlowRate}{3600}$$

Velocity in Hose (in m/s):

$$velocityHose = \frac{flowRateFromBlower}{hoseArea}$$

Velocity from Nozzle, U_0 (in m/s):

$$velocityNozzle = \frac{flowRateFromBlower}{nozzleArea}$$

Useful Equations

Dynamic pressure in hose and nozzle (in Pa):

$$dynamicPressureHose = 0.5 * densityOfAir * velocityHose * velocityHose$$
$$dynamicPressureNozzle = 0.5 * densityOfAir * velocityNozzle * velocityNozzle$$

Pressure drops in pipe, bends and nozzle (in Pa):

$$pressureDropHose = \frac{lossHoseFriction * hoseLength * dynamicPressureHose}{(hoseDiameter * 0.0254)}$$
$$pressureDropBends = numberOfBends * lossCoeffBend * dynamicPressureHose$$
$$pressureDropNozzle = lossCoeffNozzle * dynamicPressureNozzle$$

Total pressure drop in the circuit (in Pa):

$$totalPressureDrop = pressureDropBends + pressureDropNozzle + pressureDropHose$$

Updated Flow Rate from the Blower (in m^3/hr):

$$flowRate = relaxation * flowRateFromBlower + (1 - relaxation) * (blowerMaxFlowRate - \frac{totalPressureDrop}{slopeBlower})$$

Updated Flow Rate from the Blower (in m^3/s):

$$flowRateFromBlower = \frac{flowRate}{3600}$$

Useful Equations

The rate of velocity decay for a planar jet can be estimated using the following empirical formula:

$$\left(\frac{Uc}{Uo}\right)^{-2} = 0.22\left[\frac{x}{D} - 0.18\right]$$

Here, U_c = center-line velocity, U_0 = nozzle exit velocity, D = nozzle gap, x = distance from nozzle exit

Output File Information

There will be two output files.

- The summary file(.txt) that would contain the following information:

"Flow rate in m^3/s: 0.129391"

"Pressure drop in circuit in Pa: 1708.46"

"Exit Velocity from Nozzle in m/s: 71.8841"

"No. of iterations: 77"

- The Air jet output file (.csv) containing the variation of nozzle centerline velocity with the distance from nozzle exit (in mm). A graph depicting this variation will be visible on the web page.

References

- Coherent Structures in Turbulent Planar Jet - Part I, Gordeyev and Thomas, Journal of Fluid Mechanics, 2000)

Thank You !

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