Calculation of Pressure Drop Across Sunray Louvre

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Executive Summary

A louvre vent system has been developed by Sunray Engineering Ltd. A theoretical study was undertaken to estimate the pressure loss through the louvres. For the purposes of this study it has been assumed that air passes from a rectangular parallel duct, through the louvre, and then exhausts into the atmosphere (or a large outlet volume).

The static pressure drops across the louvre system are presented graphically as a function of the approaching face velocity. The pressure loss through the louvre (K factor) is 9.38.

Contents

Introduction

A louvre vent system has been developed by Sunray Engineering Ltd, the design of which is detailed in the following section.

The purpose of this study is to determine theoretically the pressure loss through the louvre vent system. The aerodynamic effects caused by the louvre blades are taken into account in the methodology used.

Louvre System

A dimensioned drawing of the Sunray louvre system is shown in Figure 1.

The external louvres consist of a single bank of louvre blades 2.5mm thick, the rake angle of which is 48^{o}. The pitch between the louvre blades is 50mm. The chord length[1] of each blade limb is 60.6mm, and there is a 16mm upstand along the top and bottom of each blade chord.

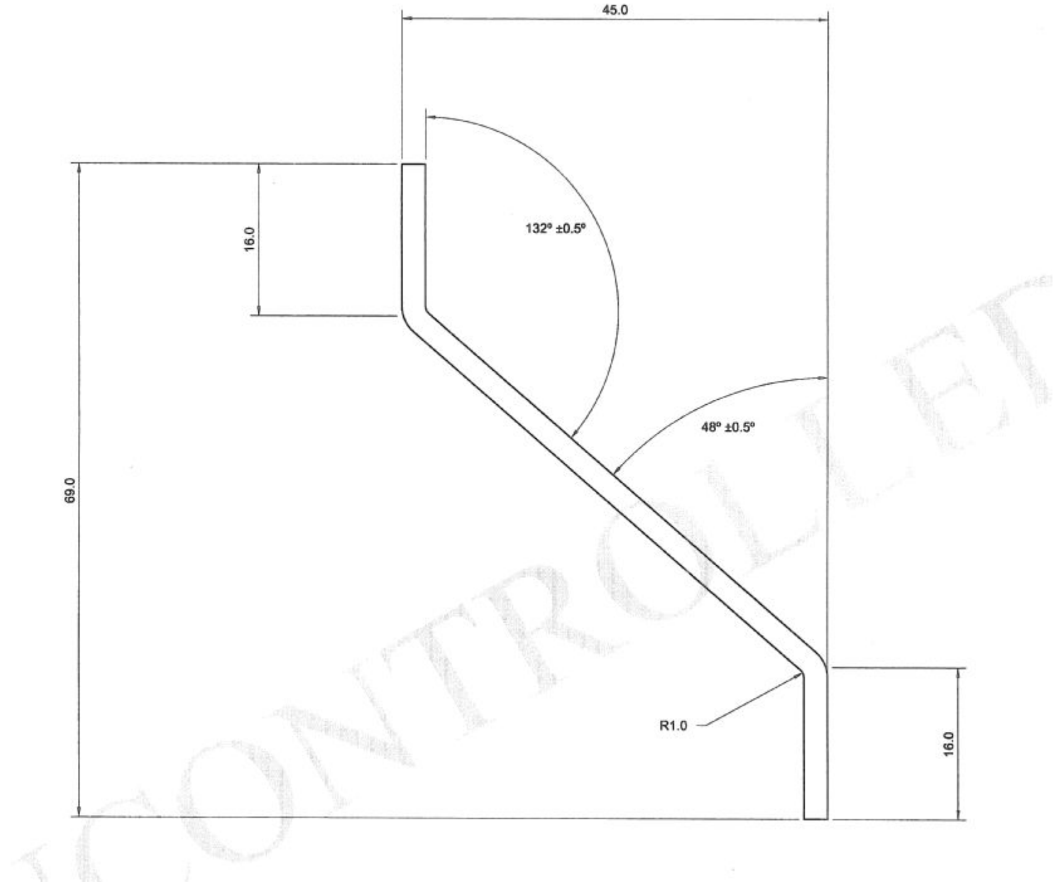

Figure 1. Section Through Louvre Blades

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[1] Blade chord length = $45/\sin 48^{o}$

Methodology

Overview

For the purposes of this study it has been assumed that air will pass from a rectangular parallel duct, through the louvre, and then exhaust into the atmosphere (or a large outlet volume).

The approach used in this study is based upon a method described in Ref[1]. In essence this method calculates the non-dimensional total pressure loss[2] through each element of the louvre system.

The non-dimensional pressure loss is defined by $\Delta P/q$, where:

ΔP is the loss of total pressure loss (Pa)
q is the dynamic pressure, defined by $\frac{1}{2}\rho V^2$,
ρ is the air density (taken to be 1.2kg/m^3)
V is the face velocity (m/s).

The non-dimensional total pressure losses across each element are added together to obtain the total pressure loss of the louvre system. The total pressure loss is related directly to the discharge coefficient, which in turn is related to the static pressure loss (Δp) across the louvre system. For a given face velocity V, the volume flow through the louvre system and its associated static pressure loss can be calculated.

Blade Louvre Pressure Loss

The pressure losses which correspond with the geometry of the louvre blades exhausting into a large volume can be estimated using results presented in Diagram 11-26 of Ref[1].

Using the nomenclature given in Ref[1], the length of the blades $l = 45/\sin 48^{\circ} = 60.6$mm, and the distance between a blade top upstand, and the blade chord above that upstand, $F_{or} = b_1' = (50 - 16)\mathrm{x}\sin 48^{\circ} = 25.3$mm. Hence the open area ratio $f = F_{or}/F_o = 25.3/50 = 0.506$, and the ratio $l/b_1' = 60.6/25.3 = 2.395$.

The parameter $(l/b_1')_{opt} = 11\mathrm{x}(1 – f) = 11\mathrm{x}(1 – 0.506) = 5.434$. Since $l/b_1' < (l/b_1')_{opt}$, total pressure loss through the blade louvres, $\Delta P/q$ (or ς) is given by $\varsigma = k\ \varsigma' + \Delta\varsigma$.

For louvres with the inlet edge cut vertically (e.g, blades with upstands), k = 1.0, and $\Delta\varsigma = 0.5\mathrm{x}[11(1 – f) – l/b_1'] = 0.5\mathrm{x}[5.434 - 2.395] = 1.52$. ς' is a function of the open area ratio f, and the value of ς' can be obtained by linear interpolation of the data shown tabulated in Diagram 11-26. Hence, for an open area ratio of 0.506, $\varsigma' = 7.0 - (0.506 - 0.5)\mathrm{x}(7.0 - 4.6)/(0.6 - 0.5) = 7 – 0.144 = 6.86$.

Therefore, total pressure loss through the blade louvres exhausting into a large volume, $\Delta P/q$ (or ς) = 1.0x6.86 + 1.52 = 8.38.

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[2] This is equivalent to the energy lost as the flow passes through or around each element

Louvre Aerodynamic Performance

Using Bernoulli's equation, it can be shown that for a parallel duct system that exhausts into, or takes air from the atmosphere, the non-dimensional static pressure drop (or K factor), $\Delta p/q$ is given by
$\Delta p/q = 1 + \Delta P/q$.

Hence the non-dimensional static pressure drop (K factor) $\Delta p/q = 1 + \Delta P/q = 1 + 8.38 = 9.38$.

For a nominal 0.2m/s flow rate (chosen with the sole purpose of illustrating the calculation process), the corresponding static pressure drop, Δp is $9.38\text{x}(½\text{x}1.2\text{x}0.2^2) = 0.23$ Pa.

Results

As shown above, the non-dimensional static pressure drop (K factor) is 9.38.

For a given flow velocity approaching the face of the louvre system, V, the non-dimensional pressure drop was converted to an actual pressure drop by multiplying by the dynamic pressure q ($q = \frac{1}{2}\rho V^2$, where the air density, ρ was taken as 1.2 kg/m^3). For a range of approaching velocities between 0 and 5 m/s, the pressure drops across the Sunray Engineering Louvre System are presented in Figure 2. For a range of approaching velocities between 0 and 1 m/s, the pressure drops are presented in Figure 3. These figures show the expected trend that the pressure drop increases with increasing flow through the louvre.

A common method of presenting the aerodynamic performance of louvres is to present pressure drop as a function of the volume flow (in litres/second, or m^3/second). However, in order to undertake such a presentation the duct area needs to be known. Multiplying the velocities shown in Figure 2 by the duct area (in m^2) gives the volume flow rate in m^3/second. The volume flow rate in litres/second can be obtained by multiplying the volume flow rate in m^3/second by 1000.

Provided the geometry of the louvre blades remain the same, Figures 2 and 3 can be used to estimate the pressure drop across different sizes and aspect ratios of the Sunray Engineering Louvre System.

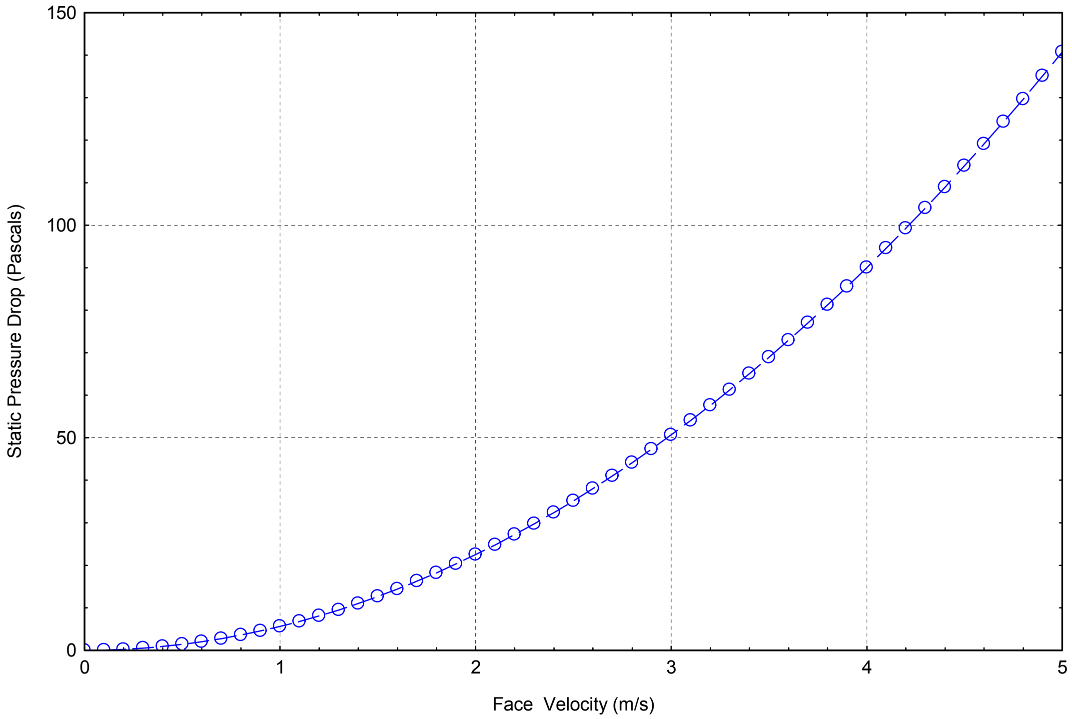

Figure 2. Pressure Drop Across Louvre as a Function of Approaching Flow Velocity (High Face Velocities)

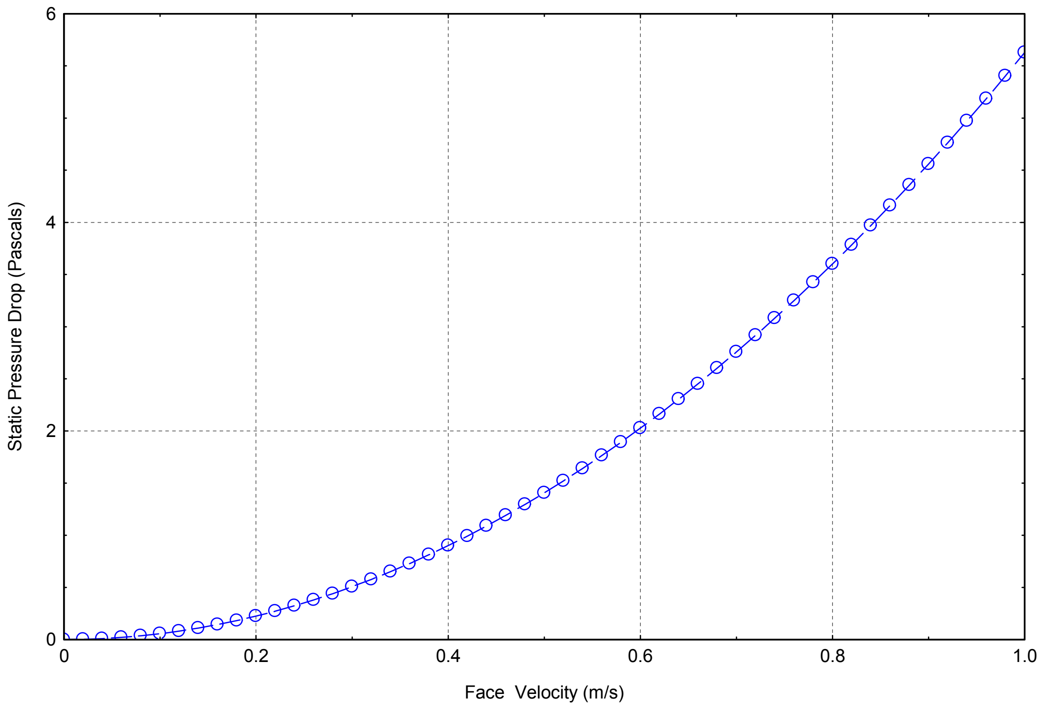

Figure 3. Pressure Drop Across Louvre as a Function of Approaching Flow Velocity (Low Face Velocities)

References

1. Idelchik IE. Handbook of Hydraulic Resistance 3rd Ed. CRC Press, 1994. ISBN 0-8493-9908-4.