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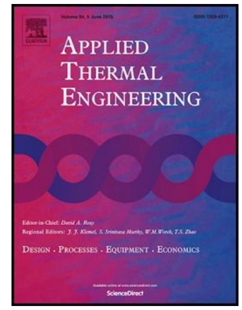

Title: Experimental investigation on the outlet flow field structure and the influence of Reynolds number on the outlet flow field for a bladeless fan

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Research Paper

Experimental investigation on the outlet flow field structure and the influence of Reynolds number on the outlet flow field for a bladeless fan

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HIGHLIGHTS

- Time-averaged velocity of each corss-section increases with increasing Reynolds number.
- Axial time-averaged velocity and turbulence intensity increase with increasing Reynolds number.
- About at the axial position of 1.5d, the annular jet starts to converge.
- The flow field combination is finished around the axial position of 3d.
- After combination the flow field behaves like a classical single jet.

Comment [A1]: Author: There are two different versions of highlights provided, and the one in the manuscript has been retained. Please check and confirm it is correct.

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ABSTRACT

The outlet flow field of an annular jet for a bladeless fan was investigated experimentally using CTA (Constant Temperature Anemometer) hot-wire system in detail, at five Reynolds numbers ranging from 28200 to 40100. From the experiment results，it can be concluded that: (1) the time-averaged velocity in both the horizontal and vertical radial directions, and the time-averaged velocity and turbulence intensity on the axis, all increase with increasing Reynolds number; (2) some variation situations of Sk (skewness) and Ku (kurtosis) of PDF (Probability Density Function) for dimensionless fluctuating velocity on the axis inversely dependents on Reynolds number, indicating that the decrease of Reynolds number intensifies the motion of large-scale coherent structures; (3) the annular jet within the outlet flow field starts to converge about at the cross-section of 1.5d (d represents the throat diameter of the Coanda surface) at each Reynolds number; the lower part of the flow field is combined upwards into the upper part; this combination has been finished about at cross-section of 3d; (4) the combined jet is similar to a classical single jet, the peak decay slope increasing with increasing Reynolds number; also, the intrinsic flow mechanism of this flow field structure has been revealed.

1 Introduction

The bladeless fan, which looks like no blades in appearance, was introduced by Dyson, an UK company in October 2009, with advantages of steady blast, safety, saving energy, portability etc. Specially, researchers have paid much attention to the annular jet used for blowing in a bladeless fan. Currently, the bladeless fan is becoming a new focus on fan research. Fig.1 shows the bladeless fan cutaway. After sucked across inlet-1 by the lower turbine, air blows upwards into the annular empty cavity of the out-wind frame, and then is injected from the narrow annular slot (about only 1.3 mm in width), forming an annular jet. Thus a slightly compressible subsonic outlet flow field [1, 2] has been developed. Due to the entrainment of the air across inlet-2 behind the out-wind frame and air front of the out-wind frame into the annular jet, the flow rate of outlet flow field increases more than ten times compared with the lower turbine intake rate (air multiplying); as a result, energy-saving effect can be achieved. Jets are widely used in aerospace, hydraulic and hydroelectric engineering, chemical industry, and energy etc. [3, 4, 5]. In researches of jets, planar, round and rectangular jets have been reported frequently [6, 7, 8]. However, annular jets have been seldom reported, and most researches on this field are focused on either the impingement jets with mass and heat transfer [9, 10, 11], or jets with a bluff-body in the center of jet nozzle [12, 13, 14]. Obviously, there are few investigations for the annular jet in a bladeless fan without a centre-body at present. The investigation of bladeless fans is very significant because it could bring about fine effects of economy and society, and further more, it could improve the fundamental theory of annular jets, consequently, it could play an active role in practice application.

Bladeless fans have promising application future in industry and in civilization, but few studies were reported about its theoretical research in the form of open academic paper. A series of simulations for bladeless fans were conducted at Zhejiang Sci-Tech university, and the effects of the inlet diameter and Coanda surface (Fig.1) curvature were investigated [15, 16]. In 2014, Zhao presented a new converged internal surface structure for the out-wind frame [17] at Zhejiang university, together with a two-stages low-speed tiny fan instead of original single high-speed fan validated via a sound level meter.

The above investigations only stated the effects of some

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