

## Review paper for fluid flow and heat transfer Through a twisted square duct numerically

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### ABSTRACT

This article is a review paper deals with the case for twisted square duct. Temperature and friction properties of air flow in twisting rectangular ducts are explored using both experiments and three-dimensional computer models. Using air with a constant heat flux flow conditions, twist ratios of 11.5 and 16.5, and Reynolds numbers ranging from 2000 to 70,000, experimentation and simulation results were carried out.

### I. INTRODUCTION

Researchers have investigated the flow impedance as well as heat transfer properties of fluid flow in twisted pipes of both square and oval cross-section, but their findings are scattered. Twisted parabolic pipe is the subject of the vast majority of research. A twisted oval tube can only be studied numerically in the Re range of 10–1000. The twisting ratios used are between 6 and 106. Twisted square duct has a dearth of analytical and simulation research. The mathematical model doesn't really cover all of the laminar or a significant portion of the turbulent flow regime. In addition, the Prandtl number range covered is somewhat limited. A high twisting ratio will have little effect on increasing heat transmission. Due of the large range of Reynolds and Prandtl number, the pressure drop and heat transfer distribution must be studied.

Technologies for improving heat transmission may be classed as active or passive, depending on whether or not external power is required. The manner of heat transmission has a significant impact on the efficacy of both strategies. Heating could occur by standard convective heat transfer or evenly distributed films heating, or a combination of the two. Latent improvement technology underpins the operation of twisting ducts. Swirling the stream is either method of improving heat transmission. An insertion (e.g., twisting tape)

may be used to enhance heat transfer via flow field in pipes (e.g., straight ones). It's not only the interior of the duct that's improved by using twisted tubing in an exchangers; the exterior as well (duct to duct space of heat exchanger bundle). Internal milky substance flow is projected to improve the rate of heat transfer from a similar amount to those of tape turbulators. Curved tapes are predicted to get a larger pressure drop than twisted ducts for the same heat transfer enhancement because it limits the flow area when it is put into the tubing.

As in previously, only just few researchers used combined numerically and experimentally methods to investigate the effectiveness of twisting tubes.

Ref [1] studied the issue of twisted tubing in generally. Under expectation of a large twisted tape, the Navier–Stokes algorithms have been simplified using a frequent perturbation technique in turning position information. According to the researcher, a high twist ratio exists when the twist degree of the duct's cross - sectional area changes relatively little in relation to the stream wise direction ( $z$ ) ( $d1/ dz$ ). An expression for the modest transverse motion of an elastic structure under continuous loading was obtained by him, and he proved that it is similar to the equation for the velocity profile. An ellipsoid tube with just an extremely high twisted tape is the only kind of pipe for which this analysis can be used.

Using the numerical solution approach, ref. [2] examined laminar flow in a twisting elliptical tube with twist ratio of 21, 53, and 106, respectively. The function of twist ratio and elliptical equivalent diameter in influencing the axial and circumferential velocities and streamline patterns was examined in this investigation.

Laminar, periodically fully developed single phase flow of a Newtonian fluid in helically twisted tube with constant wall temperature boundary condition was explored numerically by ref. [3] in the Re range of 10– 1000 and Pr of 3. Tubes with twist

ratios of 6, 9, and 12 were evaluated for their elliptical shape and twist ratios. Compared to a straight tube, a twisted elliptical tube demonstrated a significant increase in heat transmission.

To test the performance of various different twisting tubes, ref. [4] conducted an experimental study. When it comes to elliptic pipes, the twist ratio ranged from 17.4 to 32.8, as well as the aspect ratio ranged from 1.49 to 2.15. As a working medium for the Re range of 600–55,000, water was employed for laminar, transitional and turbulent regimes. It was found that for Re less than 2300, the flow in a twisting conduit stays laminar. Compared to transition and turbulent fluid properties, laminar flow enhances heat transfer more in a spiral conduit.

The flow in twisted elliptical tubes was studied numerically and experimentally by ref. [5]. Water was used as a working fluid in experiments ranging from Re 625 to Re 7000. As in the case of multi-pass heat exchangers, twisted tubes were joined at the end by a circular bend. In order to do numerical research on the turbulent flow regime, the  $k-\epsilon$  model was used. The experimental values were found to be lower than the numerical expectations. The experiments indicated that the plain circular tube performs better at low Re than the twisted tube in terms of heat transmission. Twisted tubes provide a greater heat transfer increase at higher Re than circular tubes that are plain.

Mathematical simulations by ref. [6,7] were used to investigate the steady laminar flow through twisting square ducts. In order to maintain the problem's two-dimensionality, longitudinal conductance in fluid is ignored. Each wall's temperatures was expected to remain consistent around the perimeter. This steady temperature, however, may vary from wall to wall. For a twist ratio of 2.5 and a Reynolds number range of 1–1000, the swirling motion improved heat transmission. However, the other twist ratios did not show the same improvement.

According to [5], the variable viscosity terminology employed by [6,7] has several discrepancies.

The skin friction coefficient features of laminar flow through with a longitudinally twisted corrugated channel were examined numerically by Patel et al. [9]. An investigation was conducted into the effects of twist as well as aspect ratio (ratio of rectangle's smaller side to its larger side) on cross sectional area. For a given Re and aspect ratio, lesser twist ratios resulted in higher skin friction coefficient values.

To investigate the heat transfer of laminar flow through an axially-twisted rectangular duct, Manglik and his colleagues [6] used numerical

simulations. For both constant wall temperature and constant wall heat flux boundary conditions, the heat transfer parameters were observed. Over the range of parameters tested, they discovered that the maximum heat transfer increase is around 14 times more than in an analogous straight duct.

Some experiments of a research on heat transfer or hydraulic impedance of flow of air through twisted elliptical tubes were given by Ievlev et al. [11]. Swirl ratios ranging from 6.5 to 35 are often used. There was a 3000 to 10,000 Reynolds number region covered. For the parametric study tested, it was found that twisting pipes may boost heat transmission and reduce heat exchanger measurements significantly.

The pressure drop and heat transfer performance of twisted oval tubes in a heat exchanger was tested experimentally by Tan et al. [10]. The 4000–70,000 range that was taken into consideration was the most likely outcome. In the heat exchanger, water was employed as the working fluid on both the shell and tube sides. Both the tube and the shell side results were compared to a smooth straight tube heat exchanger. Comparison indicates that the rod baffle heat exchanger has a greater shell side heat transfer coefficient and a lower shell side pressure drop. The tube side was also shown to have a greater heat transfer.

Three twisted square ducts with uniform cross section, diverging cross section, and convergent cross section throughout the duct length were examined experimentally and numerically by Wang et al. [16]. In this case, the twisted ratio is 42. Under constant wall heat flux boundary conditions, air was used as a working fluid with a Re range of 10,000–100,000. This comparison takes into account the same flow rate, pumping power, and pressure losses as a flat square duct. Divergent ducts improved heat transmission, convergent ducts degraded it, and straight ducts might improve or degrade performance depending on the comparative circumstances for the parameters evaluated.

## II. CONCLUSIONS

The numerically and experimentally investigation of the pressure decreases and heat transmission in the twisting square duct is the goal of the current work. Pressure, drop, and heat transfer coefficient for two twist ratios (11.5 and 16.5) across the Reynolds number range of 600–70,000. For twisted tube heat exchangers, the twist ratios used are in the range most typically utilized. For Reynolds numbers between 100 and 100,000 and Prandtl numbers between 0.7 and 20, numerical studies will be conducted to estimate pressure drop and heat transfer characteristics in a twisted square duct with

twist ratios of 2.5, 5, 10 and 20. An examination of local friction factor and Nusselt number distributions in the duct cross section may help explain the heat transfer enhancement process. For the purpose of providing a general correlation for computing the friction factor and Nusselt number for the complete parameter range examined selecting the right square-twisted tube is made easier thanks to this informational tool. To see how twisted square ducts stack up against twisted elliptical tubing and twisted tape in terms of strength.

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