A Study of Fluid Flow Characteristics Through Fractal Nozzles

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Abstract

The mathematics research project, "A Study of Fluid Flow Characteristics Through Fractal Nozzles," aims to apply the concept of fractal geometry to explain and analyze fluid flow behavior. Three fractal nozzle designs—Sierpiński Carpet, Koch Snowflake, and Apollonian Gasket—were compared under the same initial conditions to investigate the effects of geometric complexity on cross-sectional area, flow rate, spray angle, and droplet size. The methodology consisted of mathematical calculations and flow simulation. Fractal formulas were used to determine the effective cross-sectional area, while the continuity equation and Bernoulli's equation were applied to calculate the flow rate. Fluid dispersion was then analyzed using a mathematical model. The results showed that increasing the fractal level led to a decrease in both the cross-sectional area and the flow rate, with consistent trends observed in both the calculations and simulations. Although the calculated values were higher due to ideal assumptions that excluded flow resistance and turbulence, fractal nozzles provided more uniform fluid dispersion, wider spray angles, and smaller droplets. Among the three designs, the Koch Snowflake nozzle exhibited the greatest spray dispersion. Overall, the calculation and simulation results showed similar trends despite quantitative differences.

Keywords: Fractal nozzles, Fluid flow, Fractal geometry, Flow rate, Spray angle