Radial Jet Impingement Correlation Investigation of the Pulse Jet Mixers

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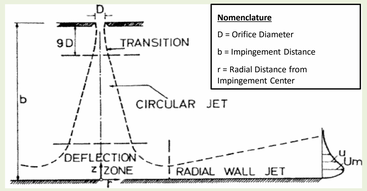
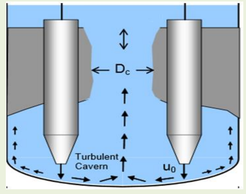
Introduction

- In the analysis of the PJMs (Pulse Jet Mixers), correlations are used to describe velocity profiles of a radial jet produced after impingement. These correlations were obtained from the paper, "Investigation of a Turbulent Radial Wall Jet" (Poreh et al.,1967). The focus of the paper was on experiments that empirically derived relationships which describe the maximum velocity and the thickness of the radial jet at different radial locations. These correlations are used to predict parameters that are critical to the performance of the PJM vessels.
- The correlations are based off a non-dimensional number that takes into account the ratio of the distance from the nozzle to the impingement surface (b) and the initial jet diameter (D). There has been skepticism on the use of these correlations since the ratios in the PJMs are much smaller than the ratio experimentally evaluated in the paper.



Schematic description of impinging and radial wall jet (Poreh et al,1967)



Section View of PJMs

Problem Statement

- Two correlations include:

$$\boldsymbol{\delta = b * .098 * \left(\frac{r}{b}\right)^{.9}}$$

$$\boldsymbol{U_m = \frac{\sqrt{K}}{b} * 1.32 \left(\frac{r}{b}\right)^{-1.1}}$$

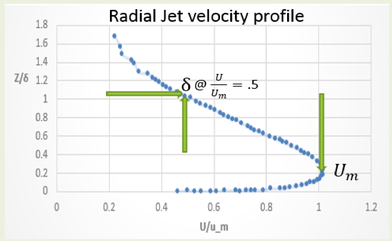
where:

$\boldsymbol{\delta}$: Distance at which U/U_m=.5

$\boldsymbol{U_m}$: Maximum velocity

b : Distance from orifice to impingement wall

- b/D ratio in experimental investigation ranged from 12 down to 8, leaving time for a fully developed profile before impingement
- PJM vessels typically have a b/D ratio of 1.5, which does not provide enough time for a fully developed jet before impingement
- Will Poreh's correlations still hold for b/D=1.5 ?

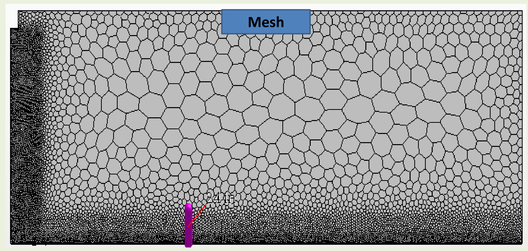


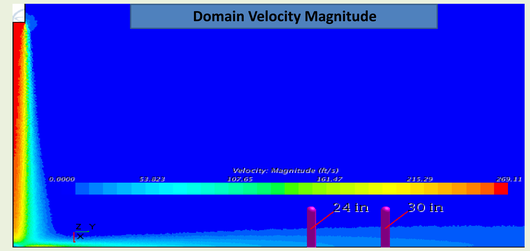
Strategic Method

Simulation of Poreh's experiment → Simulate Poreh's experiment with PJM b/D ratio → Analyze the radial jet velocity profiles

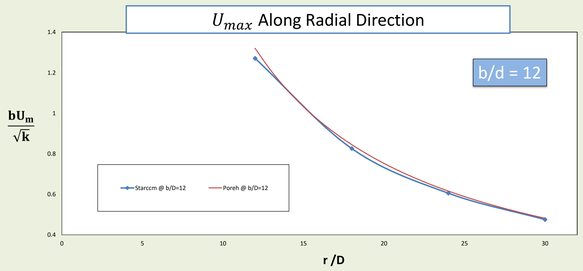
Results

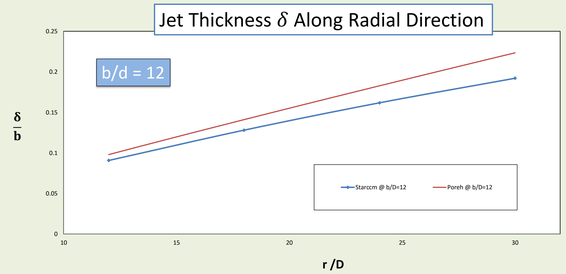
CFD Model Development



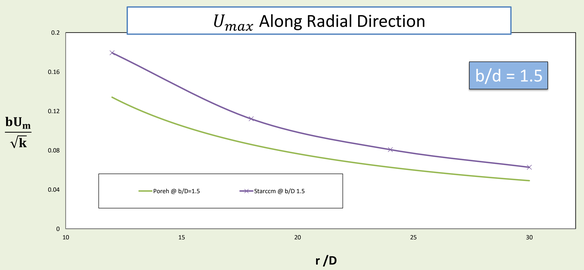


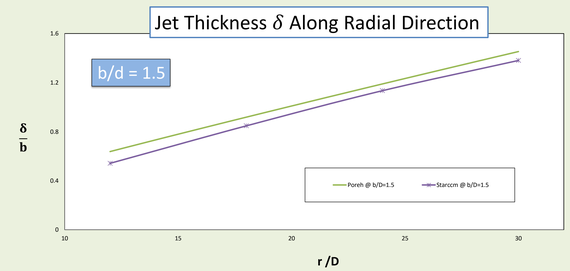
Simulation of Poreh's Experiment





Reduced b/D Ratio Results





Conclusion

- Simulation suggest Poreh's correlation decently describes maximum velocities for low b/D. For the maximum velocity, the highest discrepancy between Simulation and Poreh's correlation is 25% which decreases with increasing radial distance .Simulation jet thickness δ agrees well with Poreh's δ correlation, giving at most a discrepancy of 15% which also decreases with increasing radial distance.
- The criticism on the application of such correlations to the PJMs should lessen but not disappear. The impingement plate in the PJMs is actually at an angle. This can add gravitational effects as well as different impingement characteristics that are potentially not negligible. It is necessary that further error and geometrical analysis be performed in order to better understand the applicability of Poreh's correlation to the PJMs.

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