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Numerical Analysis Of Entry Length In Cleaning Test Rig

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Abstract

INTRODUCTION:

Fouling and cleaning processes present a major impact to the manufacturing industry in terms of economics, product quality, product safety, and plant efficiency. An efficient cleaning process is essential is order to remove fouling to maintain quality and safety of production process as well as the product. Thus, cleaning should be done with minimum cost and time, and understanding soil properties and how cleaning happened, will help in achieving the industrial goal of minimizing its costs. This study aims to investigate how forces in a hydrodynamic systems can promote/enhanced cleaning process of fat-based food fouling. An upgrade to an existing cleaning rig at the Universiti Putra Malaysia, consist of a rectangular flow channel with a test section to monitor the cleaning process was conceptually designed for this purpose. The use of computational fluid dynamic (CFD) has enabled more flexibility in the design process and similar to Sargison et al (2009), allowed a series of different design scenarios to be tested to finalize the conceptual design of the channel. The COMSOL Multiphysics 5.1 was used to test the proposed channel designs: one without settler and another with settler in the rectangular channel assembly as shown in Figure 1 & 2. Our main objectives are to visualize fluid flow pattern in the channel and to predict the best entry length, L_e where flow is fully-developed in order to decide appropriate location of the test section in the assembly.

USE OF COMSOL MULTIPHYSICS®:

CAD Import Module was used to import the 3D geometry CAD file formats from SolidWorks into the COMSOL modelling environment and provides repair and defeaturing tool to prepare the geometry for multiphysics modelling. With COMSOL CFD Module, the fluid flow was modelled using the Algebraic yPlus turbulence model as it is based on Prandtl's mixing-length theory and suitable for internal flows. It is also the most robust model and least computationally intensive compared to other turbulence models. Water was chosen as the fluid in the model. The designs were tested at different fluid velocities as inlet boundary condition, pressure at the outlet, and no slip condition for the walls.

RESULTS:

A three-dimensional CFD simulations were performed to identify a fully developed zone within the channel. For the channel with settler, the results shows similar flow trend for all different inlet velocities. Figure 3 shows that the velocity increases dramatically in the settler but quickly decreased closer to inlet value once the water flowed to the rectangular channel and then gradually stabilized after a certain length. It also shows that flow started to stabilize at around 800 mm in the x-direction length. As predicted, increased inlet velocity results in higher value of L_e for the flow to fully develop.

CONCLUSION

The new designs for the cleaning rig has been validated numerically using the COMSOL Multiphysics. From the flow profiles, the L_e value for both designs were successfully determined which then used to finalize the best design. Thus, the simulation results are critical input in order to proceed with the fabrication of the upgraded cleaning rig.

Reference

1. J.E. Sargison, A.F. Barton et al, Design and calibration of a water tunnel for skin friction research, Australian Journal of Mechanical Engineering, Vol.7, No.2, p. 111-124 (2009)

2. N.I. Khalid, N. Nordin et al, Design of a Test Rig for Cleaning Studies and Evaluation of Laboratory-Scale Experiments Using Pink Guava Puree as a Fouling Deposit Model, Journal of Food Process Engineering, Online publication: doi: 10.1111/jfpe.12188, (2015)

Figures used in the abstract

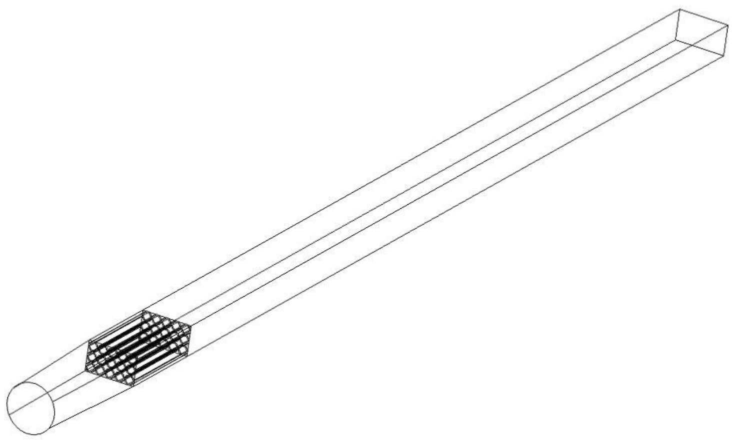

Figure 1: Proposed design of channel with settler

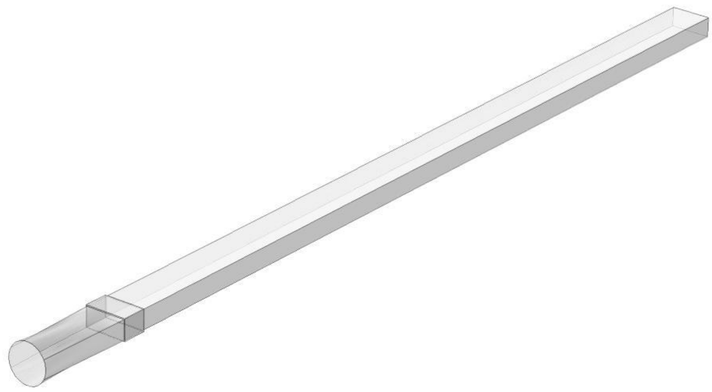

Figure 2: Proposed design of channel without settler

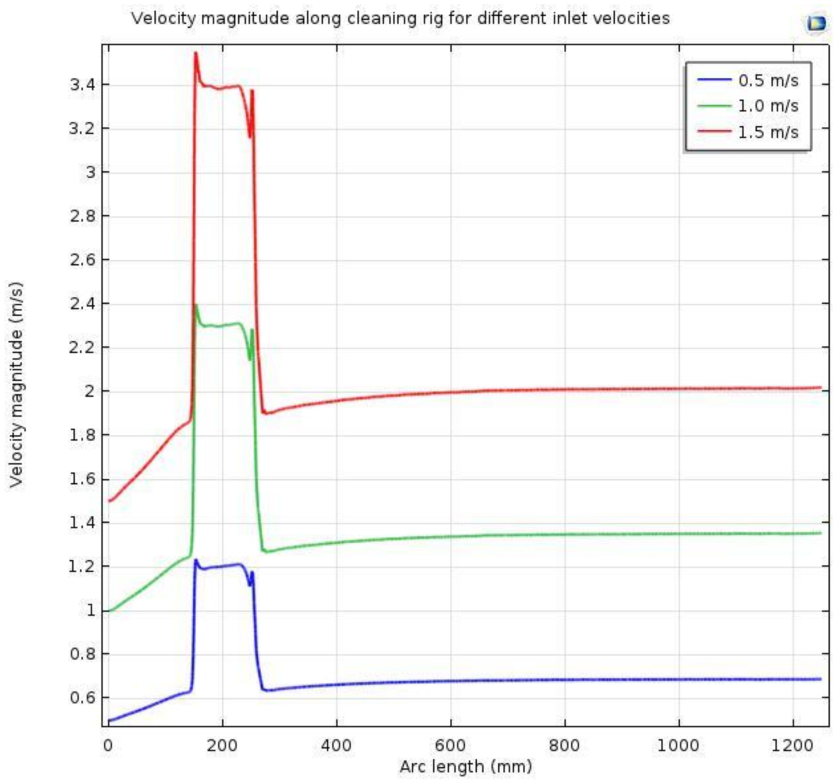

Figure 3: Velocity magnitude plot in channel with settler for all inlet velocities

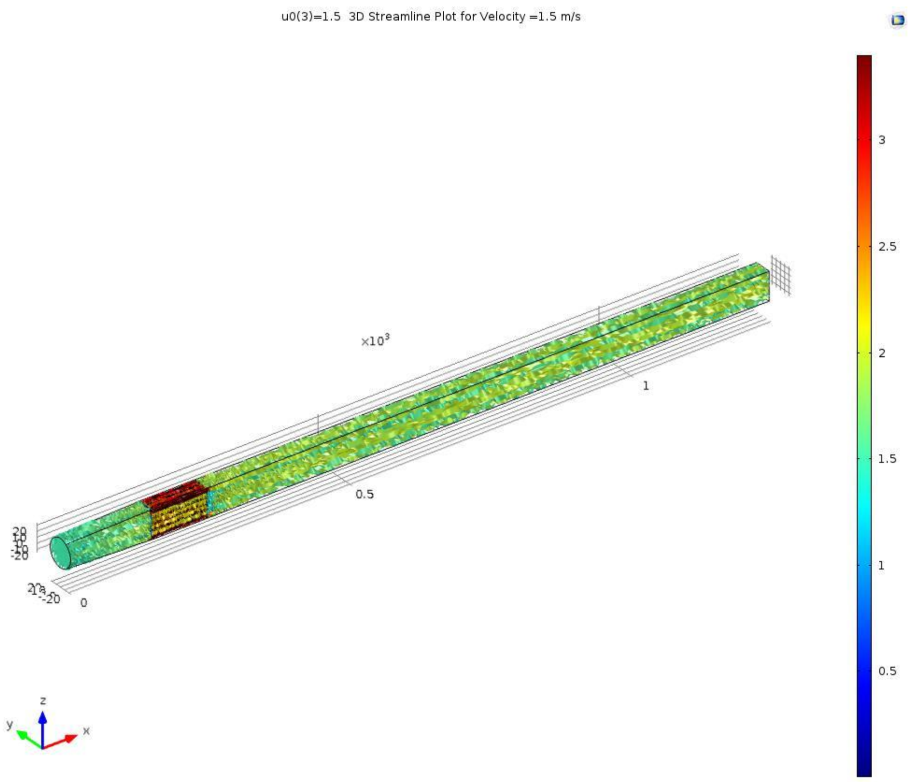

Figure 4: A 3D plot for velocity 1.5m/s in channel with settler